Louisville Metro Hazard Mitigation Plan 2016 Update

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LOJIC
Louisville/Jefferson County Information Consortium

Louisville Metro Emergency Services

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1. Executive Summary

Disasters can cause loss of life; damage buildings and infrastructure; and have devastating consequences for a community's economic, social, and environmental well-being. Hazard Mitigation reduces disaster damages and is defined as a sustained action taken to reduce or eliminate the long-term risk to human life and property from hazards.

Proactive mitigation policies and actions help reduce risk and create safer, more disaster resilient communities. Hazard mitigation and floodplain management is an investment in the community's future safety and sustainability.

Hazard mitigation activities may be implemented prior to, during, or after an event. However, it has been demonstrated that hazard mitigation is most effective when based on an inclusive, comprehensive, long-term plan that is developed before a disaster occurs.

Section 322 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act enacted under the Disaster Mitigation Act of 2000 (DMA 2000) established revitalized approaches to mitigation planning with a new requirement for Local Mitigation Plans. The Louisville Metro Hazard Mitigation Plan was developed and funded through the Pre-Disaster Mitigation (PDM) grant program and the Flood Mitigation Assistance (FMA) grant program; both part of the Hazard Mitigation Assistance (HMA) grants program of the Federal Emergency Management Agency (FEMA). The DMA 2000 emphasizes greater interaction between State and Local mitigation planning entities highlighting the need for improved linkages of hazard assessment and capability analyses. This can be accomplished through comprehensive risk assessments that form a solid foundation for decision-making, input from a wide range of stakeholders who play a key role in the implementation of mitigation actions, and who have committed to a mitigation strategy that is organized, easily referenced, and functions as a tool for tracking progress toward community resilience.

While many jurisdictions develop and utilize a stand-alone Hazard Mitigation Plan and floodplain management plan, Louisville Metro decided to combine these two planning processes into one effort. Louisville Metro has been dedicated to floodplain management for many years as proving with a Community Rating System (CRS) class of 3.

The purpose of the Louisville Metro Hazard Mitigation Plan is to set a strategy for building a more resilient community that will mitigate damages and losses caused by hazard events. The plan is the result of a systematic evaluation of the nature and extent of the vulnerability posed by the effects of hazards (risk assessment) and includes a five-year action plan to minimize future vulnerability (mitigation strategy), accompanied by a schedule that outlines a method for monitoring and evaluating plan progress (plan maintenance).

The Louisville Metro Hazard Mitigation Plan contains the following five sections, plus appendices:

- ✓ Planning Process
- ✓ Risk Assessment
- ✓ Mitigation Strategy
- ✓ Plan Maintenance
- ✓ Plan Approval

The **Planning Process** includes a narrative of how the plan was produced, who was involved, and what other policies and programs were reviewed to inform the plan. Key stakeholders were identified and organized into a steering committee and were invited to attend four publicly advertised meetings. Input provided during these meetings, work sessions, and other individual stakeholder meetings drove the formation of the risk assessment, mitigation strategy, and plan maintenance sections of the plan.

The **Risk Assessment** includes developing a profile for the 13 identified hazards as well as the identification, compilation, and integration of the existing hazard databases into one managed, database contained in Geographical Information Systems (GIS). These maps provided the necessary information for the advisory committee to examine past occurrences of hazards and assess probabilities in order to determine appropriate mitigation strategies to pursue in the future.

The **Mitigation Strategy** includes the determination of hazard mitigation goals and actions as identified during the planning process and based on a review of the risk assessment results. The plan developers also took inventory of Louisville Metro's current capabilities and marked mitigation successes over the past five years.

The **Plan Maintenance** section outlines the steps for plan implementation which includes monitoring, evaluating, and updating the plan. The plan will be maintained through collaborative efforts of the Louisville Metro departments to allow for better incorporation of existing planning mechanisms.

The **Plan Approval** demonstrates Louisville Metro's commitment to fulfilling the mitigation strategy. This section provides a description and documentation of the plan update submittal process. Following a period for public comment, Louisville Metro submits the plan to KYEM for a state level review, then makes any required revisions. KYEM then submits the plan to FEMA Region IV for review and approval, pending local adoption. Once certified approvable by FEMA, Louisville Metro will submit to Metro Council for formal adoption.

2. Introduction

Louisville Metro prepared this Hazard Mitigation Plan pursuant to the Section 322 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, 42 U.S.C. 5165, as amended by Section 104 of the Disaster Mitigation Act of 2000, P.L. 106-390 (DMA 2000) and regulations set forth in 44 CFR §201. The Plan identifies potential hazards, assesses risk, and presents mitigation strategies to build community resilience.

2.1. Scope

The Disaster Mitigation Act of 2000 (DMA 2000) requires state, local and tribal governments to have an adopted, FEMA approved hazard mitigation plan to be eligible for federal hazard mitigation and certain federal disaster recovery funding programs. DMA 2000 requires that these plans be updated on a five-year cycle. Louisville Metro's current hazard mitigation plan was adopted on October 4, 2011.

44 CFR Part 201
Mitigation Planning

§201.1 Purpose.

(a) The purpose of this part is to provide information on the policies and procedures for mitigation planning as required by the provisions of section 322 of the Stafford Act, 42 U.S.C. 5165.

(b) The purpose of mitigation planning is for State, local, and Indian tribal governments to identify the natural hazards that impact them, to identify actions and activities to reduce any losses from those hazards, and to establish a coordinated process to implement the plan, taking advantage of a wide range of resources.

The Louisville Metro Hazard Mitigation Plan (the Plan) covers the jurisdiction of Louisville Metro. In 2000, voters in Louisville and Jefferson County approved a merged city-county government to be known as Louisville/Jefferson County Metro Government, or Louisville Metro.

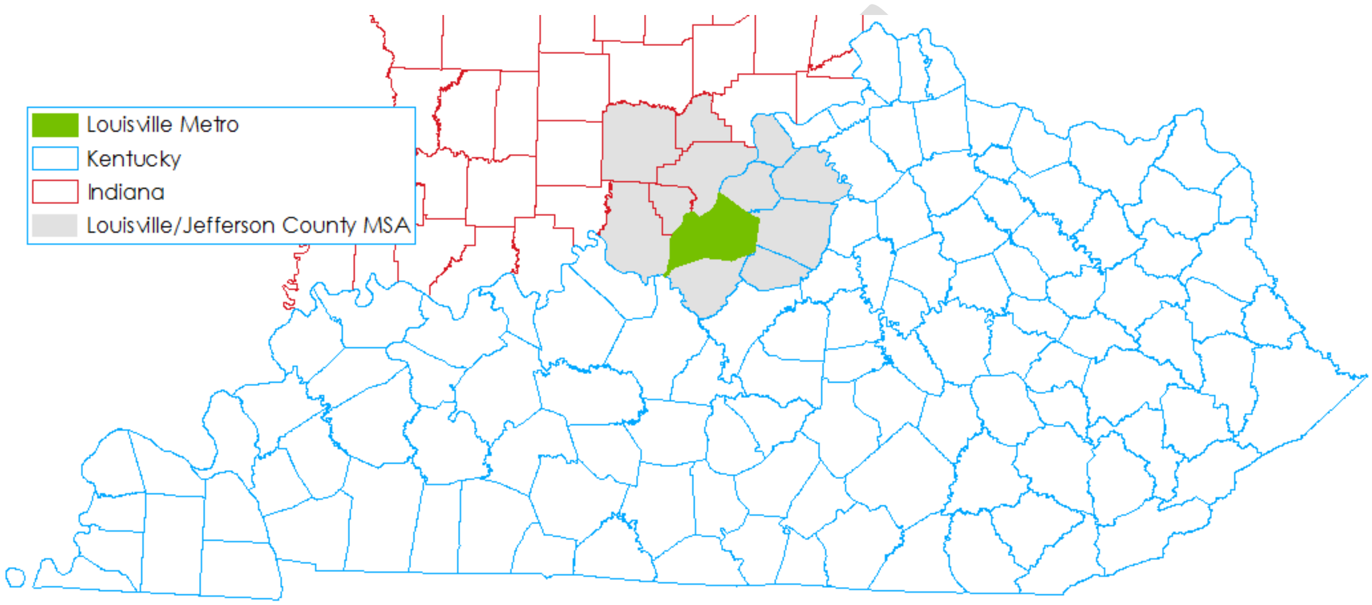
Under the authority of the Louisville Metro Council, the Louisville Metro Emergency Services Emergency Management Agency (EMA) is the authorized applicant agent and is primarily responsible for the coordination and development of the plan. The project team for the 2016 Plan Update included Louisville Metro EMA, Planning & Design Services, Louisville Metropolitan Sewer District (MSD), and the Louisville/Jefferson County Information Consortium (LOJIC). Stantec consulting provided guidance and plan development during the planning process.

Planning and Design Services (P&D), one of several offices within Develop Louisville, is responsible for Louisville Metro's Comprehensive Plan and administration of the Land Development Code. P&D will ensure coordination between the hazard mitigation plan update and the comprehensive plan update. MSD administers the Floodplain Management Ordinance, National Flood Insurance Program (NFIP), CRS program, portions of the Hazardous-Materials Ordinance, and will use this plan as their Floodplain Management Plan. LOJIC is a GIS consortium of local public and government agencies that has garnered national attention for innovative programs.

2.2. Community Profile

Louisville was founded in 1778 by George Rogers Clark. The area was settled and became a major shipping port due to the location of the Falls of the Ohio, All river boats had to be unloaded on Louisville so goods could continue downriver past the falls.

Louisville Metro is the Commonwealth of Kentucky's largest city with a population of 760,026[1]. With the merger of Louisville and Jefferson County in 2003, Louisville Metro's population includes all 83 incorporated places in Jefferson County.



Source: US Census Bureau, Geography Division

2.2.1. Geography

Louisville Metro is a 398 square mile river city located along the Ohio River adjacent to the McAlpine Locks and Dam at the Falls of the Ohio. The Ohio River separates Kentucky and Indiana. Formed in 1780, Jefferson County is a well-known geographic area highlighted by rolling hillsides and meandering streams. Approximately 790 miles of streams drain into eleven major stream systems in the Louisville Metro area.

The surface elevation of the Ohio River at downtown Louisville is approximately 420 feet, while the city's highest point located in the south central portion of the county near Jefferson Memorial Forest has an approximate elevation of 898 feet.

2.2.2. Climate

Louisville contains areas in the USDA's plant hardiness zones 6 and 7. Average precipitation is 48.49 inches and average temperature is 56.1. Louisville's winter average low temperature is 26.4 and the summer average high is 85.7.[2]

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[1] U.S. Census Bureau: State and County QuickFacts. 2014 estimate.

[2] National Climatic Data Center 1981-2010 Climate Normals.

Louisville's climate is described as "moist-continental". Winters are moderately cold with temperatures rarely below zero degrees Fahrenheit, with January being the coldest month. Average annual snowfall is about 17 inches. Summers are hot (although rarely above 100 degrees Fahrenheit) and humid, with July being the hottest month. Spring and summer months are characterized by changeable, wet weather. March has the greatest total rainfall. Yearly precipitation is approximately 43 inches. The driest month is October.

The climate of Louisville, while continental in type, is of a variable nature because of its position with respect to the paths of high and low pressure systems and the occasional influx of warm moist air from the Gulf of Mexico. In winter and summer, there are occasional cold and hot spells of short duration. As a whole, winters are moderately cold and summers are quite warm.

Temperatures of 100 degrees or more in summer and zero degrees or less in winter are rare. Thunderstorms with high rainfall intensities are common during the spring and summer months. The precipitation in Louisville is non-seasonal and varies from year to year. The percentage of possible sunshine varies from month to month with the greatest amount during the summer months as a result of the decreasing sky cover during that season. Heavy fog is unusual and there is only an average of 10 days during the year with heavy fog and these occur generally in the months of September through March.

Snowfall usually occurs from November through March. As with rainfall, amounts vary from year to year and month to month. Some snow has also been recorded in the months of October and April. Mean total snowfall for the months of January, February, and March are about the same with January showing a slight edge in total amount.

Relative humidity remains rather high throughout the summer months. Cloud cover is about equally distributed throughout the year with the winter months showing somewhat of an increase in amount. The average date for the last occurrence in the spring of temperatures as low as 32 degrees is mid-April, and the first occurrence in the fall is generally in late October.

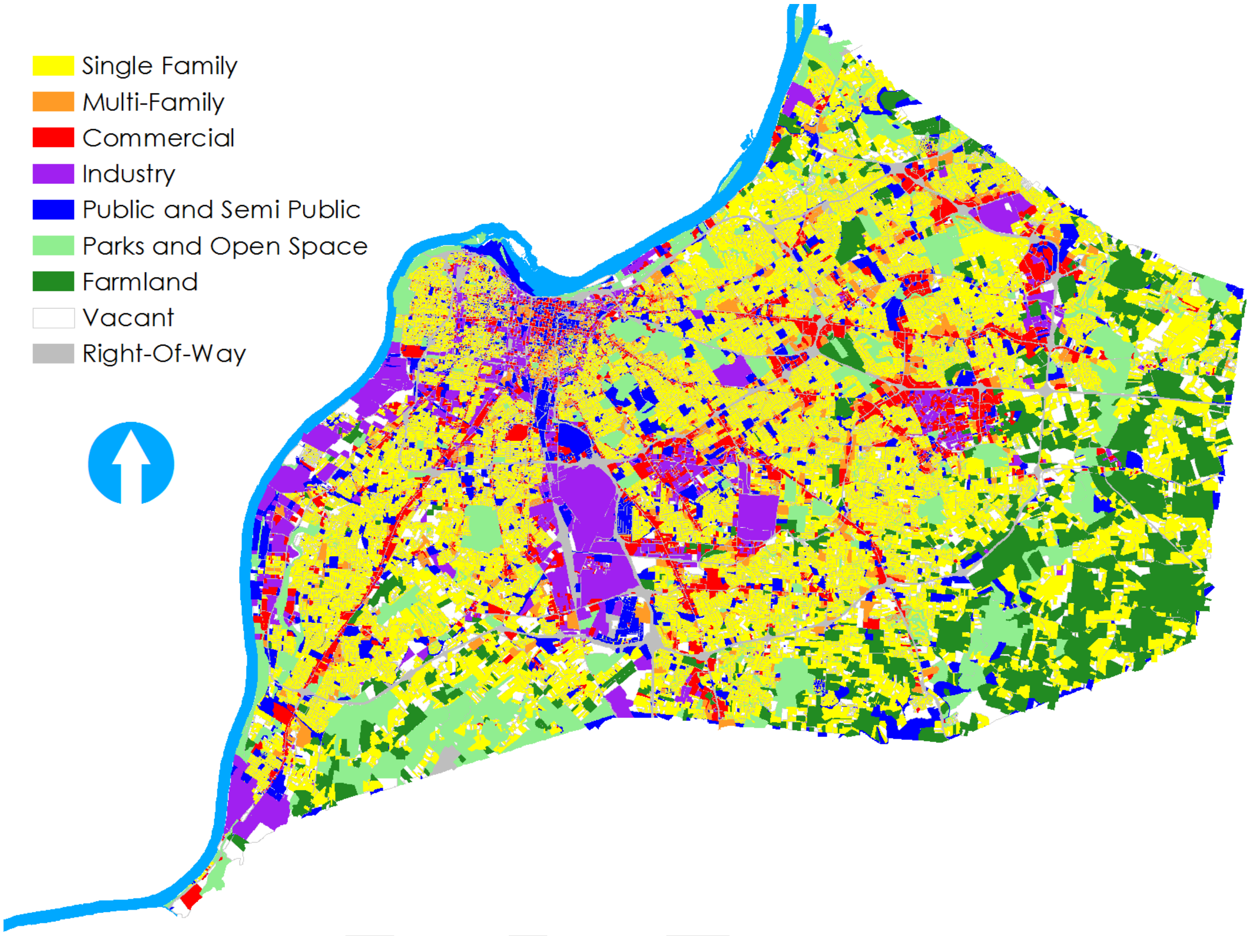
Louisville's climate change impacts will include an increase in overall temperature and an increase in frequency, intensity, and duration of extreme heat events. While precipitation projections vary, water availability will be an area of concern, because of increasing demand due to population increases and land use changes and increasing evaporation losses due to warming.[3]

2.2.3. Land Use

Land use in Jefferson County is typical of most American cities. Commercial uses are concentrated downtown, in a few suburban nodes and alone primary transportation corridors. Single family homes are the largest category of land use. Industrial uses are primarily concentrated in the western part of the county, while the eastern area is home to most of the county's farmland. Figure 1 is the county's current land use map and Figure 2 demonstrates the percentage breakdown of land uses by type.

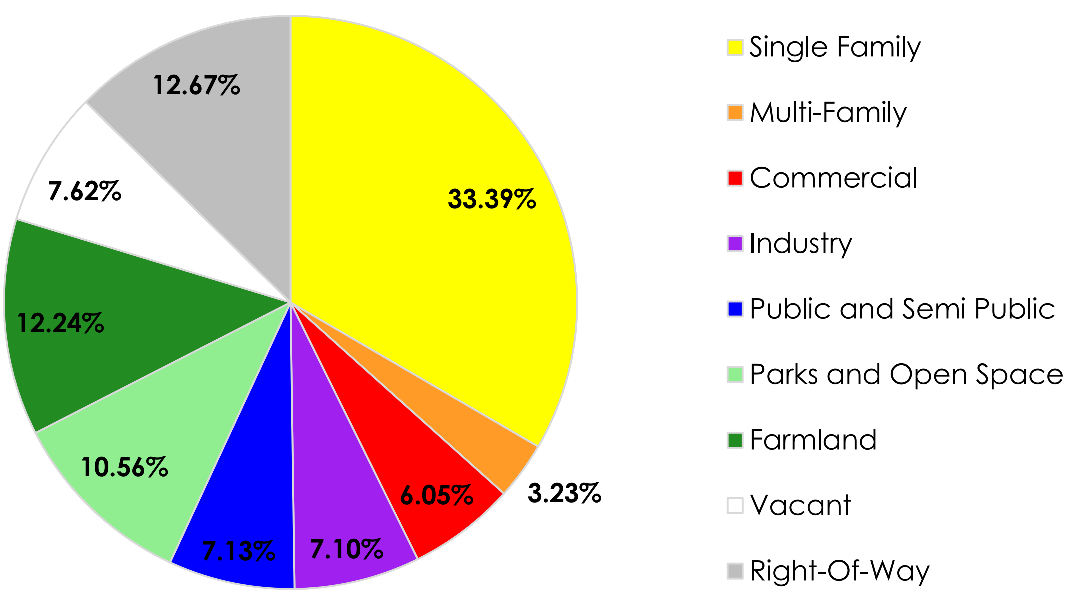
[3] US Global Change Research Program. 2014 National Climate Assessment

Figure 1. Land Use Map



Source: LOJIC

Figure 2. Land Use



Source: Stantec & LOJIC

2.2.4. Demographics

Louisville Metro's population increased by roughly 1.4% between 2010 and 2014,[4] from 741,096 to 751,485. The current population is about 52% female and almost 14% are 65 or older. Approximately 21% of the population identifies as African American, 2% as Asian, and 4.5% as Hispanic.[4]

Table 1. Selected Demographic Characteristics

	2014 American Community Survey 5-year Estimate
Total Population	751,485
Female	389,033 (51.77%)
Male	362,452 (48.23%)
65 & Over	104,080 (13.85%)
African American	155,105 (20.64%)
American Indian/Alaska Native	1,121 (.15%)
Asian	17,745 (2.36%)
Native Hawaiian	290 (.04%)
White	549,890 (73.17%)
Hispanic/Latino	34,389 (4.58%)
Multi-Racial	21,487 (2.86%)
Other Race	5,847 (.78%)
Total Households	306,511
Language other than English Spoken at Home	8.4%

Louisville officially ranks as the 30th largest city in the US by population according to the US Census Bureau's 2014 Estimates, with a population of 612,780. This number includes the City of Louisville and all of unincorporated Jefferson County and does not include the population of the county's 82 remaining incorporated places. Jefferson County's 2015 population was estimated to be 768,000 and is projected to reach 793,817 by 2020 when this plan will be updated again. The population projections below reflect the total Jefferson County population.

[4] US Census Bureau. American Community Survey 2014 5-year Estimates.

Table 2. Population Change

Year	Population/ Projection	Percent Change
1980c	684,648	
1990c	665,123	-2.85%
2000c	693,604	4.28%
2010c	741,096	6.85%
2015p	768,000	3.63%
2020p	793,817	3.36%
2025p	817,427	2.97%
2030p	838,053	2.52%
2035p	855,909	2.13%
2040p	872,231	1.91%
2045p	888,125	1.82%
2050p	904,790	1.88%

c - Census
p - Projection
Source: US Census Bureau & Kentucky State Data Center

2.2.5.Economy

Louisville has a strong manufacturing base, highlighted by two Ford Motor Company assembly plants and General Electric's Appliance Park. The city also has a robust health care sector due to the Humana headquarters and downtown's medical center being a regional healthcare center. The city is also home to a few large senior care providers, including Kindred Healthcare and Atria Senior Living. Louisville's transportation, warehousing and wholesale trade industries are similarly strong and are bolstered by the presence of United Parcel Service's (UPS) air operations headquarters, UPS Worldport, located at the Louisville International Airport.

Table 3. Business Sectors

Industry	Total Revenues	Number of Employees	Number of Establishments
Manufacturing	$28,642,125,000	40,666	718
Wholesale Trade	$13,048,420,000	15,867	1,006
Retail Trade	$10,964,388,000	41,294	2,659
Health Care & Social Assistance	$7,401,323,000	65,785	2,390
Transportation & Warehousing	$4,648,861,000	29,694	526

Source: US Census Bureau. 2012 Economic Census.

Louisville's overall economic picture reflects its position as the state's economic leader. Income, poverty, education, insurance coverage levels, and unemployment rates outperform the state as a whole. The unemployment rate for the Louisville MSA in November 2015 was 4.2%, while Kentucky's overall rate was 4.9%.[5]

Table 4. Selected Economic Statistics

	Jefferson County	Kentucky
Median Household Income[6]	$47,692	$43,342
Per Capita Income[5]	$28,464	$23,741
Income Below Poverty Level[5]	16.7%	18.9%
No Health Insurance Coverage[5]	12.2%	13.2%
Bachelor's Degree or Higher[5]	30.8%	21.8%
Unemployment Rate[7]	6.1%	6.5%

2.2.6. Geology

Geologic hazards, such as earthquakes, landslides, and sinkholes, cause millions of dollars in losses in Kentucky each year. The level and type of geologic hazards vary across the state, depending on the geology, topography, and hydrology.

For Louisville Metro, the geology consists of limestone, shale, and dolomite plus alluvial and lacustrine deposits. The five major geological areas are as follows:

1. The loam soils in the northeastern part of the county tend to overlie limestone, are relatively deep, and generally well drained. They are best suited for pasture.
2. The northern and western most parts of the county are adjacent to the Ohio River. The soils found within this area are well-drained alluvial soils with a silty sand texture. These floodplain soils represent some of the best agricultural soils in the county.
3. The central portion of the county is in poorly drained clay-based soils. Much of this area was once considered a wetland.
4. The geology within the southern part of the county is on steep slopes or upland areas. The soils are generally well-drained, moderate in depth, composed of shaly limestone or silty loam, and are best used for maintaining forested areas.
5. The southeastern part of the county is mostly hills, with moderate to steep slopes, and numerous sinkholes. The soils overlie limestone, and limestone fragments are commonly mixed into the soils. The soils are moderate to deep in most areas, generally well drained, and are a mixture of windblown sediments, silt, loam, and clays. They are well suited for forest and pasture.

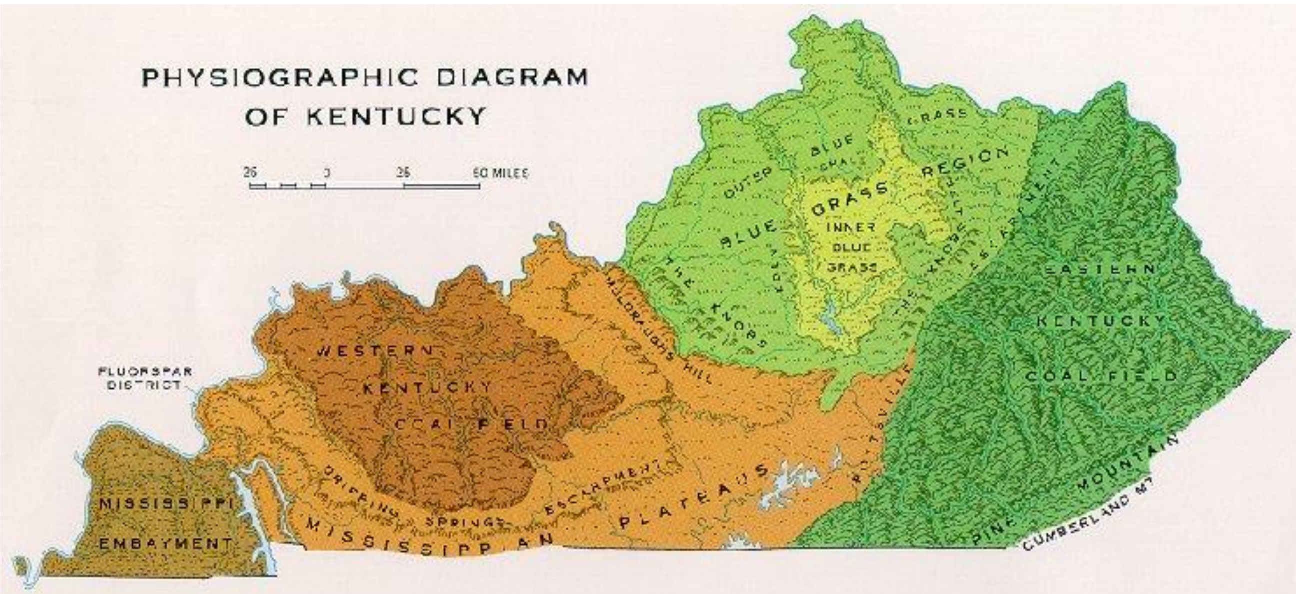
2.2.7. Topography

Kentucky can be divided into five major physiographic regions (which can be further subdivided): the Mississippi Embayment or Jackson Purchase in the west, the Mississippian Plateaus or Pennyrile, the Western Coal Field, the Bluegrass, and the Eastern Coal Field. See Figure 3 below.

[5] Bureau of Labor Statistics. Local Area Unemployment Statistics
[6] US Census Bureau. American Community Survey 2014 5-year Estimates.
[7] Bureau of Labor Statistics. 2014 Local Area Unemployment Statistics.

The Bluegrass region of Kentucky is located near the center of the state and is bordered by the Ohio River in the north and west and a ring of hills known as the Knobs in the west, south, and east. It is a rolling plateau that becomes more rugged near the edges. The underlying limestone is often visible at the surface in road cuts and where eroded by streams, most dramatically in the Kentucky River Palisades. The Bluegrass region was the most quickly settled part of the state and now is home to about half the state's population. The largest cities, including Louisville, Lexington, and the urban area of northern Kentucky are located here.

Figure 3. Physiographic Regions



Source: Kentucky Geological Survey

The map shows the extent of Kentucky's physiographic regions, the distribution of prominent topographic features that border the regions, and the general trend of major rivers. The names of some regions, such as the Knobs and the Plateaus, are descriptive; other regions, such as the Bluegrass, Jackson Purchase, and Western Coal Field, are not named for their landforms but are nevertheless well-recognized geographic areas with common socioeconomic histories related to their natural resources. Each region is characterized by distinctive landscapes produced by erosion and deposition of different rock types.

Four distinct topographic regions exist in Louisville Metro as the map shows of the regions. The four areas include Flood Plain, Knobs, Central Basin, and Eastern Uplands.

The "Flood Plain" is a strip of land bordering one-half to five miles wide along the Ohio River. The Flood Plain extends from the Salt River in the southwest, north to downtown Louisville, and continues northeast to the Oldham County line. The lowest elevations in the county are found in this region and generally range from 430 to 440, with occasional terraces to 460. The area is best characterized as flat to gently rolling and with very flat sloped stream beds. Mill Creek and the combined sewer system drain the majority of this region.

The "Knobs" region covers a triangular area in the southwestern portion of the county bounded approximately by Iroquois Park on the north, South Park Hills on this southeast, and the Southern Railroad on the southwest. The hills in this region have been highly dissected by stream erosion.

Side slopes of 30% to 50% are common, and this region contains the highest elevations in the county, probably approaching the level of the original Appalachian Plateau. These steep sided hills rise 300 to 400 feet above their surroundings and numerous streams originate here. The majority of these streams drain to Pond Creek, which has eroded a trench, effectively bisecting this region from east to west.

The west central portion of the county, bounded approximately by I-264 on the north, Shepherdsville Road on the east, and the "Knobs" region on the south and west, is the "Central Basin." This is a former slack-water region of shallow soils and nearly flat terrain with elevations ranging between 450 and 500. Various improvements to the Northern and Southern Ditch systems have helped alleviate the lack of natural drainage in the region.

The "Eastern Uplands" cover the remainder and largest portion of the county. This region is characterized by gently rolling to hilly plains to moderate to very steep valleys. Elevations range between 500 and 800. Goose Creek, Harrods Creek, Floyds Fork, and the Beargrass Creek system drain this region.

Figure 4. Topographic Regions

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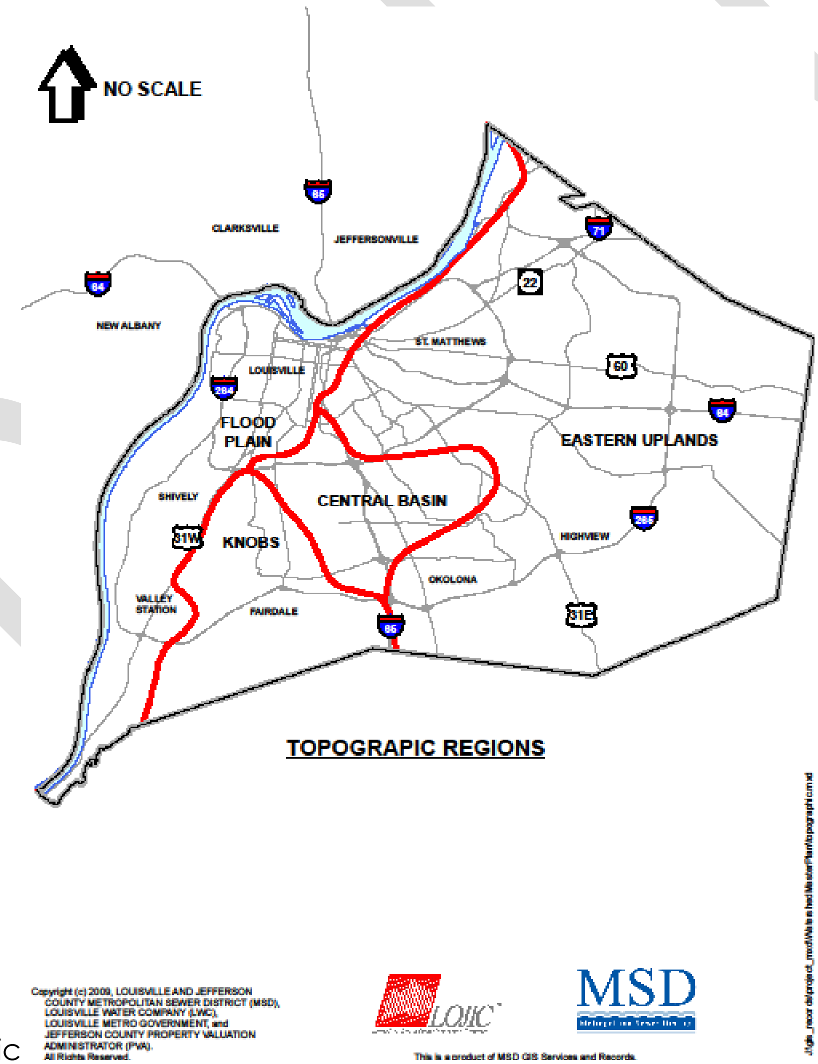


Source: LOJIC and MSD

3. Planning Process

The purpose of the planning process is to involve stakeholders and the community in crafting an update to Louisville Metro's Hazard Mitigation plan. The process also integrates FEMA's Community Rating System (CRS) program to maintain Louisville's compliance and classification level. The major components of the planning process are stakeholder and public engagement, comprehensive risk assessment, development of mitigation strategies, establishing a plan maintenance process, and plan adoption.

The project team made a decision to give the 2016 Plan Update a stronger focus on resilience. The team used this direction in creating the public engagement strategy, conducting the risk assessment and in developing mitigation strategies. During the planning process, areas at-risk in Louisville Metro were identified, mapped, assessed, and vulnerabilities determined. The resilience focus required special attention be given to socially vulnerable populations. The Plan reviews historic data, assesses vulnerability to disasters, reviews development trends and current land uses, and develops a mitigation strategy to reduce the effects of disasters and hazard events. This mitigation plan is based upon the best available data and provides a blueprint for reducing the potential losses and community impacts identified in the risk assessments.

The project team used the following guidance to complete the 2016 Plan Update:

1. FEMA Local Mitigation Planning Handbook (2013);
2. FEMA National Flood Insurance Program Community Rating System Coordinators Manual (2013)
3. FEMA Hazard Mitigation Assistance Unified Guidance (2013)
4. FEMA Mitigation Ideas: A Resource for Reducing Risk to Hazards (2013)

3.1. Stakeholder & Public Engagement

3.1.1. Project Team

The Plan's project team (Team) included representatives from Louisville Metro Emergency Management, Planning & Design Services, Louisville Metropolitan Sewer District MSD), Louisville/Jefferson County Information Consortium (LOJIC) and Stantec consulting. The Team was responsible for the planning schedule, meeting locations, and stakeholder invitations. The team also decided what mitigation strategies and actions were included in the Plan Update.

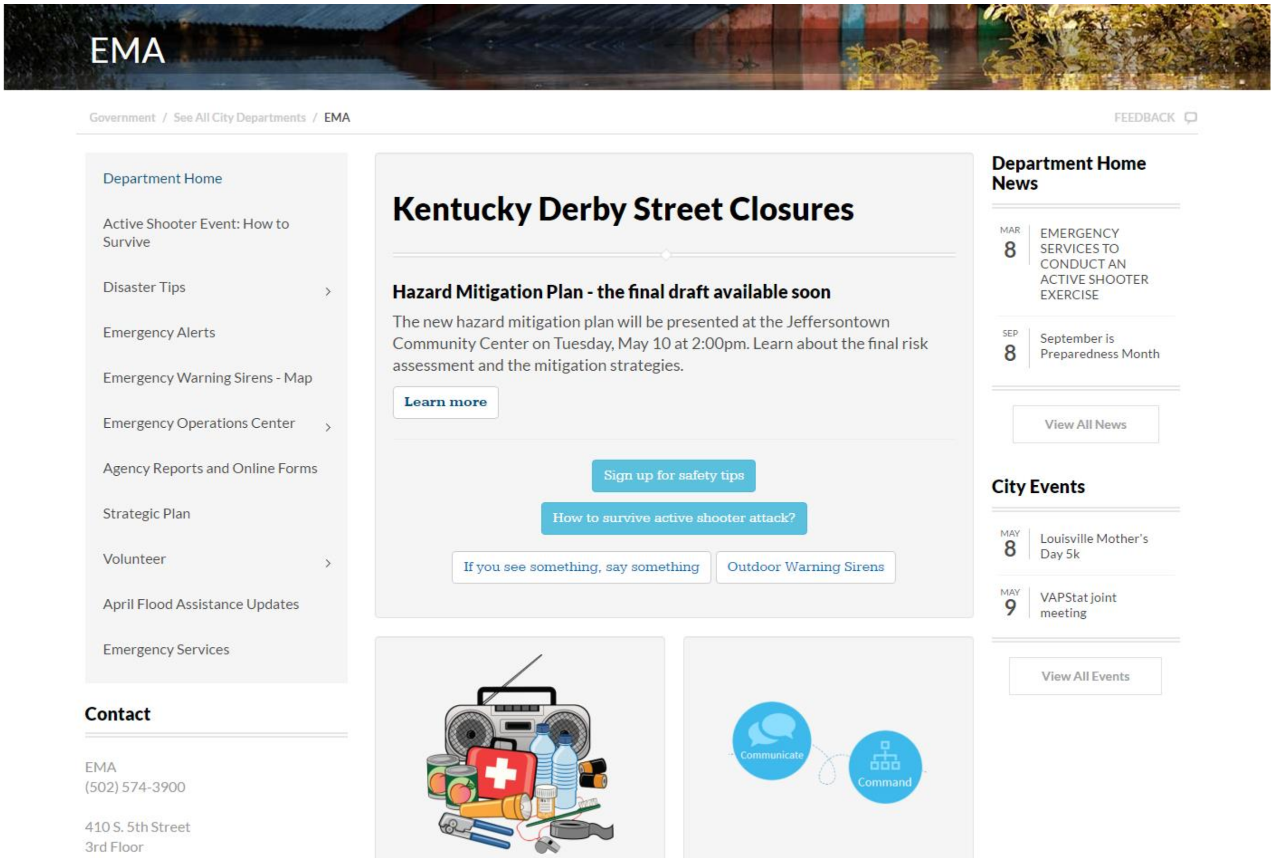
Jim McKinney	Emergency Management
Joseph Haberman	Planning & Design Services
Lori Rafferty	MSD
David Johnson	MSD
JP Carsone	MSD
Curt Bynum	LOJIC
Jess Hamner	LOJIC
Josh Human	Stantec
John Bucher	Stantec

3.1.2. Stakeholders & the Public

Louisville Metro's planning process provided an opportunity for the public to comment on the plan during its formation as well as an opportunity for any neighboring communities, local and regional agencies, businesses, and other interested parties to participate in the planning process. This public involvement, along with the review of any existing plans, studies, reports, and technical information, assisted in the development of a comprehensive approach to reducing losses from multi-disasters.

Stakeholders were identified based on previous participation in related planning efforts, and their agency's/organization's role in the community. These stakeholders were further identified as the Louisville Metro Advisory Committee. The Advisory Committee received personal email invitations to all meetings from the Director of Louisville Metro Emergency Services. Press releases, to encourage public involvement were issued prior to each meeting with the date, time, location, and topics to be covered. All press releases and meeting invitations can be found in Appendix A.

A project webpage was created on the Emergency Management website. The webpage included meeting details, contact information, and updates about the planning process. This webpage was also used to promote the process to the general public, allowing every member in the community access to the process.



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Kentucky Derby Street Closures

Hazard Mitigation Plan - the final draft available soon

The new hazard mitigation plan will be presented at the Jeffersontown Community Center on Tuesday, May 10 at 2:00pm. Learn about the final risk assessment and the mitigation strategies.

Learn more

Sign up for safety tips

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Communicate
Command

Department Home News

MAR 8 EMERGENCY SERVICES TO CONDUCT AN ACTIVE SHOOTER EXERCISE

SEP 8 September is Preparedness Month

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MAY 8 Louisville Mother's Day 5k

MAY 9 VAPStat joint meeting

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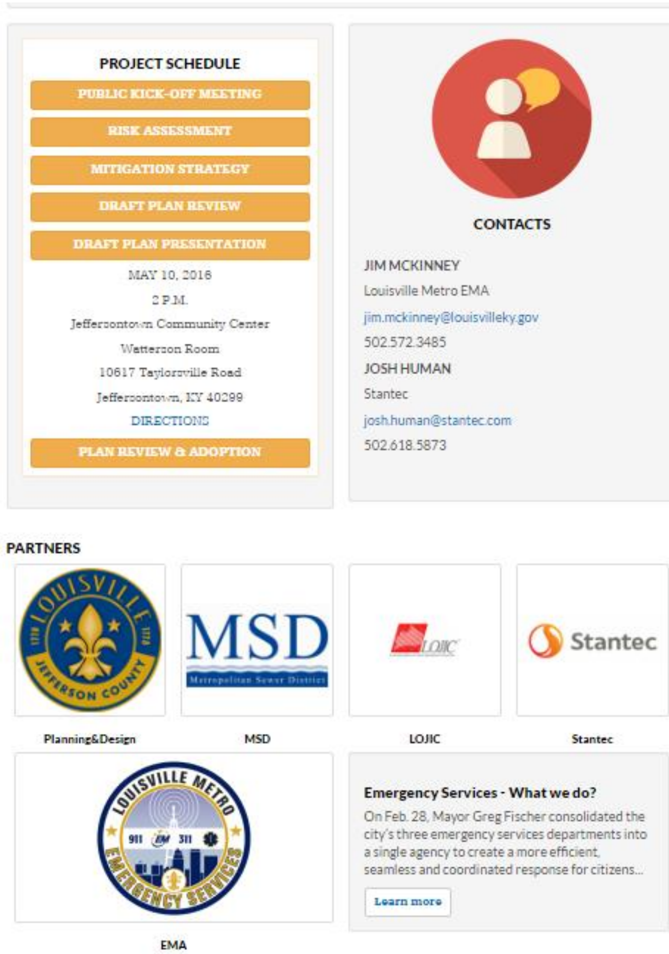


It is important to note that not only were local members of the community invited but also important state and regional partners including the emergency management agencies from surrounding counties.

A complete list of stakeholders who were invited and participated in the planning process may be found in Appendix B.

Meeting	Date	Time	Host
Project Team	November 13, 2015	3:00pm	MSD
Public Meeting #1 Kick-off & Hazard Identification	December 17, 2015	2:00pm	LG&E
Project Team Hazard Identification	January 20, 2016	3:00pm	MSD
Public Meeting # 2 Risk Assessment Workshop	February 4, 2016	2:00pm	LG&E
Project Team Mitigation Strategies	February 7, 2016	2:00pm	MSD
Public Meeting # 3 Mitigation Strategy Workshop	March 10, 2016	2:00pm	MSD

Project Team Mitigation Strategies	March 21, 2016	2:00pm	MSD
Project Team Draft Plan	March 24, 2016	2:00pm	MSD
Project Team Draft Plan Updates	April 21, 2016	2:00pm	MSD
Public Meeting # 4 Draft Plan Presentation	May 10, 2016	6:00pm	City of Jeffersontown

Kick-Off Meeting - December 17, 2015
Louisville Gas & Electric (LG&E) hosted the Plan's kickoff meeting at their East Operations Center and 59 people attended representing a wide range of stakeholders. Sign-in sheets for the meeting may be found in Appendix A. The meeting included an introduction to hazard mitigation planning, an interactive survey that will guide goal setting and rank Louisville's hazards, and a request for assistance in collecting data needed for the risk assessment. Survey results will be presented with the Risk Assessment and Mitigation Strategies.

Risk Assessment Workshop - February 4, 2016
The Risk Assessment Workshop was held at LG&E's Auburndale Operations Center in south Louisville. A total of 44 people attended the workshop. Sign-in sheets for the workshop may be found in Appendix A. Four of the project's key stakeholders gave short presentations describing their role in hazard mitigation and the types of data they contribute to the risk assessment. Presenters were Keith Alexander (LG&E), Joe Sullivan (National Weather Service), Drew Andrews (Kentucky Geological Survey), and Jess Hamner (LOJIC). The workshop concluded with a mapping exercise in which participants were asked to identify and locate hazards and hazard events on a map of Jefferson County. Worksheets submitted in the exercise may be found in Appendix A.

Individual Meetings
Stakeholders contributed specific data for the risk assessment and mitigation strategies and individual meetings were held with them. The Kentucky Geological Society contributed data related to earthquakes, landslides, and karst/sinkholes. Louisville Office of Metro Sustainability contributed data and recommendations from the Urban Tree Canopy and Urban Heat Island studies. The National Weather Service contributed data related to severe storms, tornadoes, severe winter storms, and hail. MSD contributed updated floodplain maps and stormwater data.

Mitigation Strategy Workshop – March 10, 2016
The Mitigation Strategy Workshop was held at MSD's Central Maintenance Facility in west Louisville. A total of 33 people attended the workshop and participated in the mitigation strategy activity. Sign-in sheets for the workshop can be found in Appendix A. A short presentation was given to review progress on the risk assessment and show the new risk and vulnerability maps. The bulk of the workshop was an activity in which participants updated mitigation strategies from the previous Plan and added new mitigation strategies for the Plan update. Images of the mitigation strategy posters may be found in Appendix B.

Draft Plan Presentation – May 10, 2016
The Draft Plan was presented at the Jeffersontown Community Center. Sign-in sheets and images of participant feedback will be added to Appendix A.

3.2. Integration of Existing Plans & Programs

3.2.1. Local Plans

The following plan and programs were examined and integrated into the hazard mitigation planning process.

Plan/Program	Type	Owner	Status
Cornerstone 2020	Comprehensive Plan	Louisville Metro, Louisville Forward	Update in process, to follow mitigation plan
Floodplain Management Ordinance	land development regulation	Louisville Metro, Louisville Forward	Active, adopted September 1997
Karst Ordinance	land development regulation	Louisville Metro, Louisville Forward	Active, adopted July 2008
Steep Slopes Ordinance	land development regulation	Louisville Metro, Louisville Forward	Active, adopted March 2006
Erosion Prevention Sediment Control Ordinance	land development regulation	Louisville Metro, Louisville Forward	Active, adopted November 2000
Hazardous Materials Ordinance	County ordinance	Louisville Metro	Active, adopted July 1993
Vision Louisville	25-year Vision Action Plan	Louisville Metro, Louisville Forward	Complete, in implementation
Move Louisville	long range strategic multimodal transportation plan	Louisville Metro, Louisville Forward	In progress
Louisville/ Jefferson County Emergency Operation Plan	emergency operations	Louisville Metro, Emergency Services	Updated 2014
Louisville/ Jefferson County Hazardous Material Commodity Flow Analysis	HazMat flow analysis	Louisville Metro, Emergency Services	Completed August 2012
Climate Action Report	plan to mitigation impacts of climate change	Partnership for a Green City	Completed April 2009
Sustain Louisville	Sustainability Plan	Louisville Metro, Louisville Forward	Completed March 2013
Louisville Urban Tree Canopy Assessment	Assessment with recommendations	Louisville Metro, Louisville Forward	Completed 2015
Urban Heat Management Study	Assessment with recommendations	Louisville Metro, Louisville Forward	Draft Completed April 2016
Horizon 2035	Metropolitan Transportation Plan	KIPDA	Completed August 2014
KIPDA Regional Hazard Mitigation Plan	hazard mitigation plan	KIPDA	in process
National Climate Assessment	climate change impact report	US Global Change Research Program	Completed May 2014
Silver Jackets	Coordination/Collaboration Program	MSD	In Development

Plan/Program	Type	Owner	Status
Levee Emergency Preparedness Plan	Emergency	MSD	Active
CRS Floodplain Outreach	Public Outreach	MSD	Active
Snow Removal Plan	Emergency Operations	Louisville Metro, Public Works	Active
Evacuation Plan	Emergency Operations	Louisville Metro, Emergency Services	Active
Stormwater Management Master Plan	stormwater management	MSD	Active, Adopted August 2010
Stormwater Quality Management Plan	stormwater quality, NPDES compliance	MSD	
Integrated Overflow Abatement Plan	sewer overflow prevention	MSD	Active, adopted August 2005
MSD Facilities Plan	Capital improvement	MSD	Active

The most common themes in these plans and programs are related to floodplains, stormwater and trees. Most address Louisville's flooding concerns due to stormwater in some way, and several call for additional trees to alleviate flooding, air quality issues and urban heat concerns. Several include requirements related to development in the 100 and 500 year floodplain.

Cornerstone 2020

Louisville Metro's comprehensive plan, Cornerstone 2020, was in the update process at the same time as the hazard mitigation plan. The updated comprehensive plan will have a resiliency element informed by the hazard mitigation plan and the 2016 Hazard Mitigation Plan Update will be adopted as an amendment to the new comprehensive plan.

Floodplain Management Ordinance

Louisville Metro's Land Development Code includes a floodplain ordinance adopted in 1997. The ordinance outlines specific development standards for areas within the floodplain. The purpose of this chapter is to maximize the wise and safe use of the flood prone areas of Jefferson County and to ensure that flood levels are not increased and to minimize public and private losses from flooding

Karst Ordinance

The purpose of this part is to guide development in karst terrain areas consistent with Cornerstone 2020 Comprehensive Plan guidelines, to protect natural areas and features and to locate development, where possible, in areas that do not have severe environmental limitations. The intent of this part is to regulate karst terrain development in order to protect the public health, safety and welfare by regulating the development and use of environmentally constrained lands to proceed in a manner that promotes safe and appropriate construction, storm water management and ground water quality.

Steep Slopes Ordinance

The purpose of this part is to guide development in steeply sloped or unstable hillside areas consistent with Cornerstone 2020 Comprehensive Plan guidelines, to protect natural areas and features and to locate development, where possible, in areas that do not have severe environmental limitations.

Erosion Prevention Sediment Control Ordinance
This Ordinance is intended to conserve, preserve and enhance the natural resources of Jefferson County by controlling the adverse impacts and offsite degradation of soil erosion and sedimentation arising from land disturbing activities including single family, commercial, residential and utility construction.

Hazardous Materials Ordinance
The purpose of this chapter is for the protection of public health and safety in Louisville Metro, through prevention and control of hazardous materials incidents and releases and to require the timely reporting of releases thereto.

Vision Louisville
Completed in 2015, Vision Louisville is a 25-year Vision Action Plan. The plan is focused on implementation and includes several project recommendations that involve riverfront development and one that calls for planting 500,000 trees.

Move Louisville
Move Louisville is a long-range strategic multi-modal transportation plan. Move Louisville was in progress as the time of the 2016 hazard mitigation plan update.

Louisville/Jefferson County Emergency Operations Plan (EOP)
Provides direction and control during any large scale disaster, to include preparedness, response, recovery, and mitigation.

Louisville/ Jefferson County Hazardous Material Commodity Flow Analysis
this report is to present information on patterns of hazardous material commodity flow along I-64, I-65, I-71 and Highway 841, as observed from June 11, 2012 to August 2, 2012. This report also summarizes incidents involving hazardous materials over the previous 3 years, August 2008 to June 2011, in the Louisville Metro area. Finally, this report assesses survey information collected from fixed facilities that ship and receive hazardous materials in the Louisville Metro Area. Presents series of recommendations including data collection, information sharing, mapping incidents, training,

Climate Action Report
Recommended strategies to mitigate the community's GHG emissions and to prepare for the impact climate change may have locally.

Sustain Louisville
Presented a series of goals and initiatives related to energy, environment, transportation, economy, community, and engagement. Initiatives include green roofs, reduction of impervious surfaces, riparian restoration, land development code changes, green infrastructure, tree canopy, outreach/education.

Louisville Urban Tree Canopy Assessment
Determine the historic and current amount and location of tree cover, quantify the benefits, set realistic goals to expand the tree canopy, and make recommendations for achieving these goals. The report prioritizes planting areas, strategies for caring for existing trees and planting new

trees. Specifically calls for planting trees and reforesting CSO#'s 257, 142, 155, 160, 82, 106, and 137.

Urban Heat Management Study
Commissioned by the Louisville Metro Office of Sustainability, this study is the first comprehensive heat management assessment undertaken by a major US city and constitutes one component of a broader effort to enhance livability, health, and sustainability in the Louisville Metro region. Recommendations from the Urban Heat Management Study are incorporated into the Extreme Heat mitigation strategies in the Plan Update.

Stormwater Management Master Plan
The promotion of stormwater drainage management practices in the context of a regional program. Plan includes project recommendations for each of the county's 11 watersheds.

Stormwater Quality Management Plan
The Stormwater Quality Management Program is described as functional areas of responsibility that help protect and improve the water quality in our streams. These areas include Public Education, Outreach, Participation & Learning Experiences (PEOPLE), Illicit Discharge Detection and Elimination (IDDE), Industrial Program (IP), Construction Site Stormwater Runoff Controls (CS), Post-Construction Stormwater Runoff Controls (PC), Good Housekeeping and Pollution Prevention (GH/P2), Monitoring Programs (M), and Program Assessment and Reporting (PAR).

Integrated Overflow Abatement Plan
The IOAP is a long-term plan to improve water quality, control combined sewer overflows (CSOs), and eliminate sanitary sewer overflows (SSOs) throughout the county.

Horizon 2035
Regional Transportation Plan completed by KIPDA, determines funding priorities for transportation projects. Some attention is paid to 100 and 500 year floodplains in certain roadway projects.

Regional Hazard Mitigation Plan
Regional hazard mitigation plan completed by KIPDA for surrounding counties: Trimble, henry, Oldham, Shelby, Spencer, and Bullitt.

National Climate Assessment
Outlines expected changes in local climate. Increase in heat and average temperature, combined with increased development could result in water supply concerns.

Silver Jackets
Team of agency representatives working in hazard mitigation, emergency management, floodplain management, natural resources management that facilitates coordination of programs to utilize different capabilities and best practices and to leverage resources.

3.2.2. CRS Integration

Community Rating System (CRS) and Flood Mitigation Act (FMA) planning requirements were integrated into to hazard mitigation planning process to ensure coordination and leverage funding opportunities. In addition to the DMA 2000 Planning Requirements, the CRS 10-step planning and floodplain management requirements were utilized to guide the Louisville Metro planning process with a particular focus on flooding and repetitive loss. The CRS 10-step planning process is consistent with the multi-hazard planning regulations under 44 CFR Part 201

CRS Ten-Step Planning Process	Disaster Mitigation Act of 2000 Planning Requirements
Organize Involve the Public Coordinate	Planning Process
Assess the Hazard Assess the Problem	Risk Assessment
Set Goals Review Possible Activities Draft Action Plan	Mitigation Strategy
Adopt Plan	Plan Adoption
Implement, Evaluate, & Revise	Plan Review, Evaluation, & Implementation

4. Risk Assessment

The 2016 Louisville Metro Hazard Mitigation Plan (Plan) assesses the community's risks and vulnerabilities. This section is to be used as the blueprint for the mitigation strategy. The risk assessment section uses best available data. This includes the first-hand knowledge of individual stakeholders, local, state and national datasets, and the use of Geographic Information System (GIS). GIS provides the capabilities to perform an accurate risk assessment and to indicate specific spatial areas of vulnerability to each identified hazard.

This section of the Plan follows the "Local Mitigation Plan Review Tool" section "Hazard Identification and Risk Assessment" element B. The requirements for this section are described below:

- Does the Plan include a description of the type, location, and extent of all natural hazards that can affect each jurisdiction(s)? (Requirement §201.6(c)(2)(i))
- Does the Plan include information on previous occurrences of hazard events and on the probability of future hazard events for each jurisdiction? (Requirement §201.6(c)(2)(i))
- Is there a description of each identified hazard's impact on the community as well as an overall summary of the community's vulnerability for each jurisdiction? (Requirement §201.6(c)(2)(ii))
- Does the Plan address NFIP insured structures within the jurisdiction that have been repetitively damaged by floods? (Requirement §201.6(c)(2)(ii))

To complete the elements required for the Risk Assessment section the project team decided to use a similar methodology established in other Kentucky based Hazard Mitigation Plans. This included breaking this section into three areas of examination.

1. Identify Hazard
2. Profile Hazard
3. Assessing Vulnerability

Each identified hazard was developed with one continuous Risk Assessment overview. This provides an independent review of each hazard following the three sections described above (Identify, Profile and Assessing Vulnerability). In addition, it allows the end users the ability to review all facets of each hazards complete Risk Assessment within one section.

Throughout the risk assessment, GIS spatial data provides the baseline for the risk assessments developed for the Plan. GIS provides the architecture to facilitate an inventory of assets and hazards as well as providing the platform to calculate a geographic based risk assessment. The maps developed through GIS production are used whenever possible to convey where spatially defined risks and vulnerable areas are located, thus should be considered for a mitigation opportunity to make the community more resilient.

The maps and data layers created from this production provide a visual tool for analysis as well as the capability to use this information in GIS to identify very specific areas of unmet need and high risk. Creating this data in a GIS layer format extends the usage of the data by allowing other interested parties to add these data layers into their own GIS mapping environments. Finally, the information developed throughout this section was guided and developed using the best available data. This included the former local hazard mitigation plan, the approved 2013 Kentucky Hazard Mitigation Plan, and many other sources, see References.

4.1. Identifying Hazards: Overview

This section provides a complete overview and definition of each hazard that could potentially affect Jefferson County. A complete understanding of each hazard better prepares decision makers, local agencies and residents on the causes of, potential damages contributed to, and possible scenarios of each hazard identified in the Plan.

The plan includes hazards where there is a historical record of damage caused to people and property or where the potential for such damage exists within the area. Due to Louisville's climate, geology, and geographical setting, the community is vulnerable to a wide array of hazards that threaten life and property.

Through research of historic impacts, occurrences, dollar losses to date, review of the past State and Local Hazard Mitigation Plans and discussions with key agencies and stakeholders, the following thirteen (13) hazards are assessed in the 2016 Louisville Metro Hazard Mitigation Plan:

Flood Related Hazards

Flood
Dam/Levee Failure

Meteorologic Hazards

Tornado
Severe Winter Storm
Severe Storm
Hailstorm

Geologic Hazards

Earthquake
Landslide
Karst/Sinkhole

Other Hazard Types

Hazardous Materials
Drought
Extreme Heat
Wildfire

As mentioned before, each hazard will have an individual "Identify" section where the hazard will be described and defined. In order to understand the general public's view of hazards in the community during the Kick Off meeting held on December 17th, 2015 the stakeholders went through a Hazard Ranking exercise. The results of this process are found in Table 5 below. This ranking process helped the team prioritize the hazards based on the input from local stakeholders.

Table 5. Hazard Ranking

Hazard		Score
1	Flooding	3.76
2	Tornadoes	3.75
3	Winter Storms	3.63
4	Severe Storms	3.52
5	Hazardous Materials	3.06
6	Extreme Heat	2.66
7	Earthquakes	2.56
8	Karst/Sinkholes	2.34
9	Hailstorms	2.27
10	Dam/Levee Failure	2.20
11	Drought	1.96
12	Landslides	1.30
13	Wildfires	1.02

4.2. Profiling Hazards: Overview

As noted in the last section, due to Louisville's geology, climate, and geographical setting, the metro area is vulnerable to a wide array of natural hazards that threaten life and property. The following section profiles those hazards previously identified as affecting Louisville (see section titled, Identifying Hazards).

The Louisville Metro Hazard Profiles have been created using the best available data from a variety of resources, including but not limited to the National Centers for Environmental Information (NCEI), formerly the National Climatic Data Center (NCDC), National Weather Service (NWS), LOJIC, Corps of Engineers: Louisville District, Kentucky Office of Geographical Information, Kentucky Geological Survey (KGS), Kentucky State Climatology Center, Midwestern Regional Climate Center (MRCC), FEMA Hazard Mapping website, local agencies and newspaper articles, previous Local Hazard Mitigation Plan's, and the approved 2013 Kentucky Enhanced State Hazard Mitigation Plan.

Public input was an invaluable local resource throughout the planning process. Stakeholder members attended steering committee/stakeholder meetings, completed a hazard identification and ranking exercise, and discussed information gathered from the sources listed above as well as their own general knowledge. Steering committee members discussed particular issues such as, past events and significant occurrences that did not warrant a declared disaster and how those events impacted the university community and properties.

4.2.1.1. Kentucky's Declarations

The profile section provides the historical context for identifying the hazards and a good indicator of hazards affecting a community is to review a presidential declaration table. Table 6 lists all of Kentucky's declared disaster since 1957. Disasters in red are those that included Jefferson County.

Table 6. Kentucky's Declared Disasters

Number	Date	Incident Description
4239	8/12/2015	Severe Storms, Tornadoes, Straight-Line Winds, Flooding, Landslides, And Mudslides
4218	5/12/2015	Severe Winter Storm, Snowstorm, Flooding, Landslides, And Mudslides
4217	5/1/2015	Severe Storms, Tornadoes, Flooding, Landslides, And Mudslides
4216	4/30/2015	Severe Winter Storms, Snowstorms, Flooding, Landslides, And Mudslides
4196	9/30/2014	Severe Storms, Flooding, Landslides, And Mudslides
4057	3/6/2012	Severe Storms, Tornadoes, Straight-Line Winds, And Flooding
4008	7/25/2011	Severe Storms, Tornadoes, And Flooding
1976	5/4/2011	Severe Storms, Tornadoes, And Flooding
1925	7/23/2010	Severe Storms, Flooding, And Mudslides
1912	5/11/2010	Severe Storms, Flooding, Mudslides, And Tornadoes
1855	8/14/2009	Severe Storms, Straight-Line Winds, And Flooding
1841	5/29/2009	Severe Storms, Tornadoes, Flooding, And Mudslides
1818	2/5/2009	Severe Winter Storm And Flooding

3302	1/28/2009	Severe Winter Storm
1802	10/9/2008	Severe Wind Storm Associated With Tropical Depression Ike
1757	5/19/2008	Severe Storms, Tornadoes, Flooding, Mudslides, And Landslides
1746	2/21/2008	Severe Storms, Tornadoes, Straight-Line Winds, And Flooding
1703	5/25/2007	Severe Storms, Flooding, Mudslides, And Rockslides
1617	12/1/2005	Severe Storms And Tornadoes
3231	9/10/2005	Hurricane Katrina Evacuation
1578	2/8/2005	Severe Winter Storm And Record Snow
1537	8/6/2004	Severe Storms And Flooding
1523	6/10/2004	Severe Storms, Tornadoes, Flooding, And Mudslides
1475	7/2/2003	Severe Storms, Flooding, Mud And Rock Slides, And Tornadoes
1471	6/3/2003	Severe Storms, Flooding, Mud And Rock Slides, And Tornadoes
1454	3/14/2003	Severe Winter Storms
1414	5/7/2002	Severe Storms, Tornadoes And Flooding
1407	4/4/2002	Storms And Flooding
2384	11/2/2001	Kentucky River Fire Complex
2385	11/2/2001	Southeastern Fire Complex
2386	11/2/2001	Eastern Fire Complex
1388	8/15/2001	Severe Storms And Flooding
2350	11/4/2000	Eastern District Fire Complex
2349	11/4/2000	Southeastern District Fire Complex
1320	2/28/2000	Severe Storms And Flooding
1310	1/10/2000	Tornadoes, Severe Storms, Torrential Rains And Flash Flooding
2288	11/20/1999	Eastern District Fire Complex
1216	4/29/1998	Severe Storms, Tornadoes And Flooding
1207	3/3/1998	Severe Winter Storm
1163	3/4/1997	Severe Storms/Flooding
1117	6/1/1996	Severe Storms/Tornadoes
1089	1/13/1996	Blizzard
1055	6/13/1995	Severe Storm, Tornadoes, Hail
1018	3/16/1994	Severe Storm, Freezing Rain, Sleet, Snow
3104	3/16/1993	Severe Snowfall And Winter Storm
893	1/29/1991	Flooding, Severe Storm
846	10/30/1989	Severe Storms, Mudslides, Flooding
834	6/30/1989	Severe Storms, Flooding
821	2/24/1989	Severe Storms, Flooding
705	5/15/1984	High Winds, Tornadoes, Flooding
670	9/29/1982	Flash Flooding
636	3/17/1981	Sewer Explosion, Toxic Waste
592	7/19/1979	Severe Storms, Flash Floods
568	12/12/1978	Severe Storms, Flooding
529	4/6/1977	Severe Storms, Flooding
468	5/24/1975	Severe Storms, Flooding
461	3/29/1975	Severe Storms, Flooding
3009	3/19/1975	High Winds

420	4/4/1974	Tornadoes
381	5/11/1973	Severe Storms, Flooding
332	5/15/1972	Heavy Rains, Flooding
305	5/10/1971	Tornado
288	6/5/1970	Severe Storms, Flooding
282	2/2/1970	Heavy Snowmelt, Rains, Flooding
265	7/15/1969	Severe Storms, Flooding
237	5/4/1968	Tornadoes, Severe Storms
226	3/27/1967	Severe Storms, Flooding
163	3/17/1964	Severe Storms, Flooding
148	3/13/1963	Severe Storms, Flooding
128	3/12/1962	Floods
66	1/31/1957	Flood

Source: http://www.fema.gov/disasters

4.2.1.2. Profiling Hazards

In order to stream line the dissemination of hazard information the project team developed a common format within the profile section to display multiple layers of information, including information on previous occurrences, probabilities, types, locations and information on extent. To provide the end users with a snap shot of each hazard and how it has impacted Louisville Metro, the project team developed a "Profile Risk Table" for each hazard. These tables provide a comprehensive overview and summary of the historical perspective of each hazard and how they have affected the community. The following table describes the "Profile Risk Table" along with an explanation of each data element.

Profile Risk Table	
Period of occurrence:	When does this hazard occur?
Number of events:	Number of recorded events
Probability of events:	Probability of the event occurring, calculated using occurrence data
Past Damages	Record of damages in NCEI Storm Events Database
Warning time:	Average warning time for this type of hazard – factor of Extent
Potential impact:	The potential impact this hazard could produce
Potential of injury or death:	The potential this hazard could cause injury or death
Possible Extent:	How bad could it be?

It is important to note that the data captured within these tables was derived from the National Centers for Environmental Information (NCEI) Storm Events Database in order to have a standardized and single source of data. It is recognized that this data can vary from other sources identified in the plan (FEMA worksheets etc.), but in order to show consistency for the Profile Risk Table the project team decided to use a recognized national data set.
Within each hazards profile section the following elements will be found:

- A "Profile Risk Table", which summarizes the overall risk.
- A local definition of each identified hazard and potential impact.
- Historical background on each identified hazard and a brief description of known events including a description of extent.

Understanding risk and each hazards potential effect on Louisville Metro is imperative to the mitigation strategy and provides the information needed to understand the overall risk to the community. Table 7 below is a "Loss Matrix" table and provides quantitative data that portrays which hazards have the potential to cause the most devastation based on frequencies and damage numbers where available. The data was used by the project team to help prioritize which hazards should receive the most consideration when justifying potential mitigation projects. This loss and occurrence data is then used to calculate a basic loss estimation model based on the number of events divided by the total number of damages. As always this data can be improved and Louisville Metro is dedicated to keeping better loss information in order to improve the results of this model.

The source of data for the loss matrix was the National Centers for Environmental Information (NCEI) Storm Events Database, which as mentioned above provides a consistent and single source of data. Louisville Metro currently does not have a source for loss data for HazMat, karst/sinkhole, landslides, and wildfires.

Table 7. Louisville Metro Loss Matrix:

Hazard	Start Range	End Range	Range	Frequency	Total Losses	Probability	Average Consequences	Average Annualized Loss	Deaths
Dam Failure				0	N/A	N/A	N/A	N/A	
Flooding	1996	2015	20	127	$ 251,915,000	6.35	$ 1,983,583	$ 12,595,750	2
Severe Storm	1957	2015	59	452	$ 3,552,000	7.66	$ 7,858	$ 60,203	3
Severe Winter Storm	1996	2015	20	27	$ 105,000	1.35	$ 3,889	$ 5,250	3
Tornado	1964	2013	50	23	$ 5,705,000	0.46	$ 248,043	$ 114,100	3
HAZ/MAT	2010	2015	6	1,179	N/A	196.50	N/A	N/A	
Hail	1961	2015	55	152	$ 20,017,000	2.76	$ 131,691	$ 363,945	
Karst/ Sinkhole *			1	443	N/A	N/A	N/A	N/A	
Drought	1945	2015	71	32	N/A	0.45	N/A	N/A	
Earthquake				0	N/A	N/A	N/A	N/A	
Extreme Heat	2011	2012	2	3	N/A	1.50	N/A	N/A	2
Landslide	1993	2015	23	5	N/A	0.22	N/A	N/A	
Wildfire	2000	2016	17	6	N/A	0.35	N/A	N/A	

*Occurrences are recorded sinkholes.

The Loss Matrix table provides a snap shot view of the damages each hazard has manufactured. The flooding has displayed the most potential to do damage to Louisville Metro with severe storms occurring more frequently. It is important to note, that hazards without damage records due to underdeveloped record keeping should still be considered a risk to Louisville Metro. Following this discussion point many hazards have a very low probability but a potentially high magnitude, such as earthquakes.

4.3. Assessing Vulnerability: Overview

The Assessing Vulnerability section uses best available data and modeling techniques from national, state, and local data sources. The model used for the Louisville Metro plan follows the State's Vulnerability Assessment Model and the 2005 and 2011 Louisville Metro Hazard Mitigation Plan.

This model is very flexible and can be adjusted to fit the data and needs of particular organizations. The model provides an understanding of relative risk and vulnerabilities from hazards across the community. Uncertainties are inherent in any vulnerability/risk assessment, arising in part from incomplete scientific knowledge concerning natural and man-made hazards and their effects on the built environment. Uncertainties can also result from approximations and simplifications that are necessary for a comprehensive analysis (such as incomplete inventories, demographics, loss data or economic parameters).

The Louisville Metro Vulnerability Assessment incorporates multiple models that have been developed and data resources, and assimilates them into a specific model for this Plan. FEMA requires state and local partners to assess the jurisdiction's overall vulnerability to population, property, infrastructure and critical facilities. The project team, using the best available data and methods, assessed the vulnerability and risks surrounding the Louisville Metro community.

One of the most important steps in creating a vulnerability assessment model within GIS is to define the geographic unit of measurement. Through the creation of the last two Louisville Metro Hazard Mitigation Plans, the project team has continued to develop a risk assessment model that has become more granular. During the creation of the 2011 plan the project team developed a census block level assessment.

This model produced a more equal playing field but still tended to get skewed in areas that were more rural, based on the fact that the census blocks within these areas were typically larger in size. The lack of equal area distribution caused the census block model to still have some particular issues when comparing individual census blocks due to the unequal size of each census block.

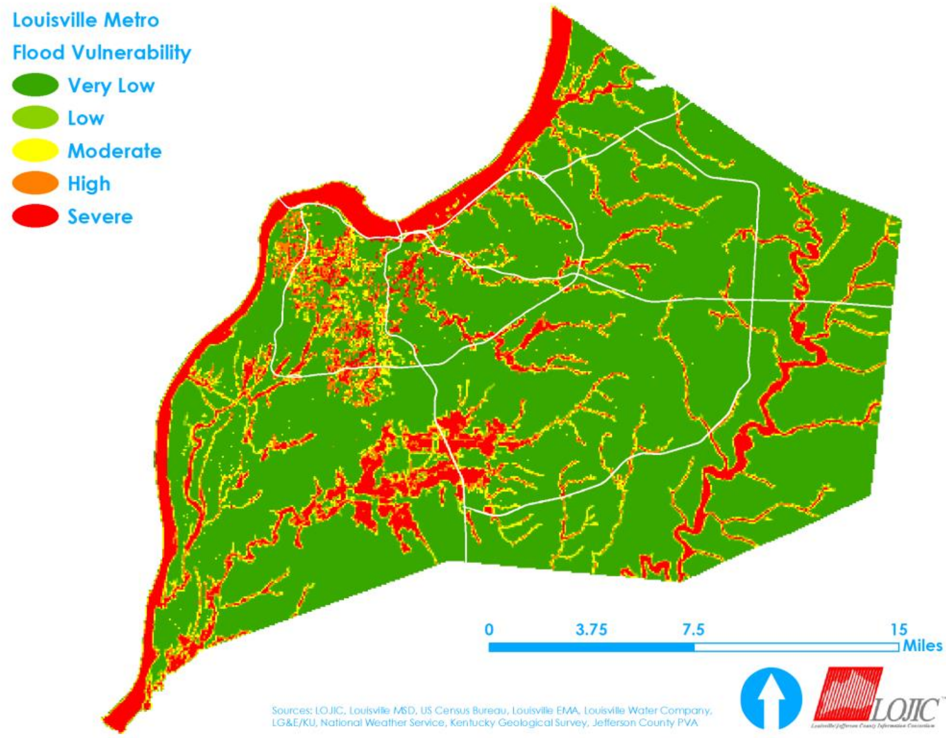
Using lessons learned from developing the 2013 State Hazard Mitigation Plan Risk Assessment model, the project team developed a model that was extremely granular and thus very useful to pinpoint specific areas of potential hazard extent issues and areas needed to be reviewed for mitigation options. The geographic unit of measure for this plan is a 100 meter (M) grid derived from the Military Grid Reference System (MGRS). The MGRS was chosen based on the equal area distribution of each grid cell and the fact that the military based grid system can also be used during response and recovery efforts. This model allows the end user to extrapolate hazard and exposure data into geographically equal sized areas. The Grid-Level Risk Assessment Model specifically provides the following improvements:

1. Equal area calculations based on each unit being equal sized
2. Allows better comparisons between planning areas in different parts of the County
3. Improved visual interpretations of risk and vulnerability
4. Potential for better policy decisions and dollar allocation
5. Granular data enhances the potential usage for other planning processes
6. Military grid provides enhanced usage during response and recovery

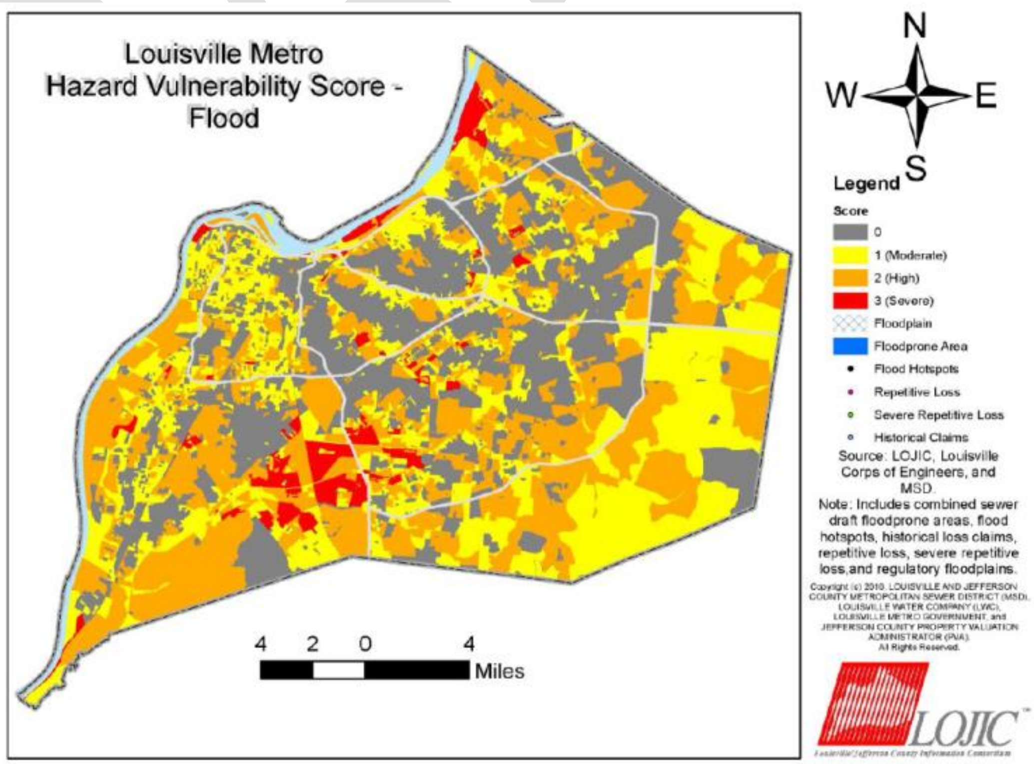
The Grid-Level Risk Assessment methodology provides enhanced data and more refined information for policy and decision makers. There are a total of 103,920 individual grids across the county. The main goal of this model is to supply a model that can be easily informed with a variety of data resources and models, while also providing a model that demonstrates equivalent comparisons across the area of assessment. Using the 100M grid cell model provides the data to be influenced by a variety of data resources and provides 100M grids to assess each hazard equally across the entire planning area.

Below displays the differences between a census block level assessment model versus 100M grid assessment model. While both are displaying relative risk one can clearly see the better distribution of spatial definition using the 100M grid assessment model. This data will be much more useful for the Louisville Metro stakeholders in understanding where mitigation should occur as well as being useful for future response and recovery efforts.

2016 Vulnerability Map
100m Grid Level Analysis



2011 Vulnerability Map
Census Block Level Analysis



4.3.1. Model

There are multiple models that attempt to determine risk and hazard vulnerability. The project team relied heavily on the Stantec staff's knowledge of the "Risk Assessment" research field to develop the vulnerability assessment model used for the Plan.

Stantec's staff researched and conducted test runs to develop an updated methodology for Louisville Metro's Risk Assessment. The revised model relies heavily on GIS spatial analyses and provides the user with several layers of integrated information which can be used individually to display different planning scenarios, such as densities of populations, buildings, and socially vulnerable populations. As mentioned, to facilitate data collection and analysis, the project team collected data at 100M grid level. This approach enabled the creation of a Hazard Vulnerability Score for each hazard at the 100M grid spatial level.

In order to calculate vulnerability for the Louisville Metro area, the project team used the "Hazard Vulnerability Score" methodology.

Hazard Vulnerability Score = Exposure Score + Risk Score

To achieve the Hazard Vulnerability Score the Exposure Score and Risk Score are first scored from 0-1 based on the highest number being 1. The two scores were then added together and a new 0-1 score was calculated for each grid cell. Exposure and Risk each account for 50% of the Hazard Vulnerability Score. In order to visualize the data on the Hazard Vulnerability Maps each Hazard Vulnerability Score is categorized as follows, Low, Moderate, High, and Severe, based on the Natural Breaks (Jenks) classification, which breaks data into like classes. These categories are displayed within the legends of each vulnerability map. By categorizing the 100M grids on the map into these categories it provides the end user the ability to quickly identify which areas are more vulnerable and thus need more consideration for mitigation opportunities. The Hazard Vulnerability map provides a visual display of the potential extent of each hazard within Louisville.

4.3.1.1. Exposure Score

In order to define Louisville Metro's vulnerability, it is critical to complete an inventory of the assets that can be potentially ***exposed*** to a hazard. These identified assets comprise Louisville Metro's Exposure Score. Each 100M grid received an Exposure Score rank from 0-1. Where 1 = the highest value for that category and 0 = the lowest value for that category. The following is a complete description of each of the six (6) exposure variables that created the Exposure Score.

Exposure Score = Population Score + Socially Vulnerable Score + Property Score + Critical Facilities Score + Infrastructure Score + Government Facilities Score

Exposure Score = (Cell Total – Minimum Cell Total)/ Range

Population Score

To calculate the population score, people were assigned to each primary building in the building footprint shapefile obtained from LOJIC. The total population of each Block Group was divided by the number of addresses in the Block Group. Next, for each building, the population per address was multiplied by the number of addresses in each building, resulting in a population for each building. The building totals were then aggregated to the 100 meter grid and a 0-1 score was calculated for each grid cell. Population data was obtained from the American Community Survey 2014 5 –year Estimates.

Social Vulnerability Score

Social Vulnerability was calculated similarly to population. Census Block Group totals for each of the variables listed below were divided by the number of addresses in the Block Group and then multiplied by the number of addresses in each building to give a building total for each variable. The building totals were then aggregated to the 100 meter grid for each variable and the grid cells were given a 0-1 score for all social vulnerability variables. All of these scores were added together and a new 0-1 score was calculated based on the total score for each grid cell. Social vulnerability data was obtained from the American Community Survey 2014 5 –year Estimates.

Social Vulnerability Variables	
Poverty	total in poverty
Disability	total with a disability
Education	total with less than Bachelor's degree
Employment	total unemployed
Linguistically Isolated	total that speak English "not well" or "not at all"
Age	total under 5 and over 65
Health Insurance	total without health insurance

Property Score

The Property Score includes the total number of buildings in each grid cell and the combined value of all properties in the grid cell. A 0-1 score was calculated for the total number of buildings and a 0-1 score was calculated for the total value of the properties in the grid cell. Those two score were added together and a new 0-1 score was calculated resulting in the Property Score. Property data was obtained from LOJIC and the Jefferson County PVA.

Critical Facilities Score

The Critical Facilities Score includes the total number of critical facilities located within each grid cell. A 0-1 score was calculated for each type of facility based on the total number of facilities in each cell. The scores for all types of facilities were added together and a new 0-1 score was calculated for the total score. Critical facility locations were obtained from LOJIC.

Critical Facility Types	
EMS Sites	Emergency Operations Centers
Hospitals	Post Offices
Nursing Homes	Daycares
Schools	Colleges
Detention Centers	Groceries
Religious Facilities	Shelters
Theaters	Sports Facilities
Hotels	Museums
Office Buildings	Shopping Centers
Manufacturing Facilities	Convention Centers

Government Facilities Score
The Government Facilities Score includes the total number of government facilities and their combined value (if available). All government facilities were counted in each grid and a 0-1 score was calculated. Next, all available property values (values for many publically owned facilities is not available) were totaled for each grid cell and a second 0-1 score was calculated. These two scores were added together and a new 0-1 score was calculated resulting in the government Facilities Score. Government facilities include police stations, fire station, and all other Metro, State and Fe government federal properties. Important to note that new Government Facility data was used for this plan based on a project complete over the last five years funded by a FEMA grant. Government facilities data was obtained from LOJIC.

Infrastructure Score
The infrastructure Score includes utility and transportation infrastructure. The amount of infrastructure in each cell was calculated by adding up facilities, such as pump stations, and adding up the total liner feet of utility lines, such as electrical lines. A 0-1 score was calculated for each infrastructure type. Those scores were added together and a new 0-1 score was calculated for each grid cell, resulting in the Infrastructure Score. Infrastructure data was obtained from LOJIC, MSD, and LG&E.

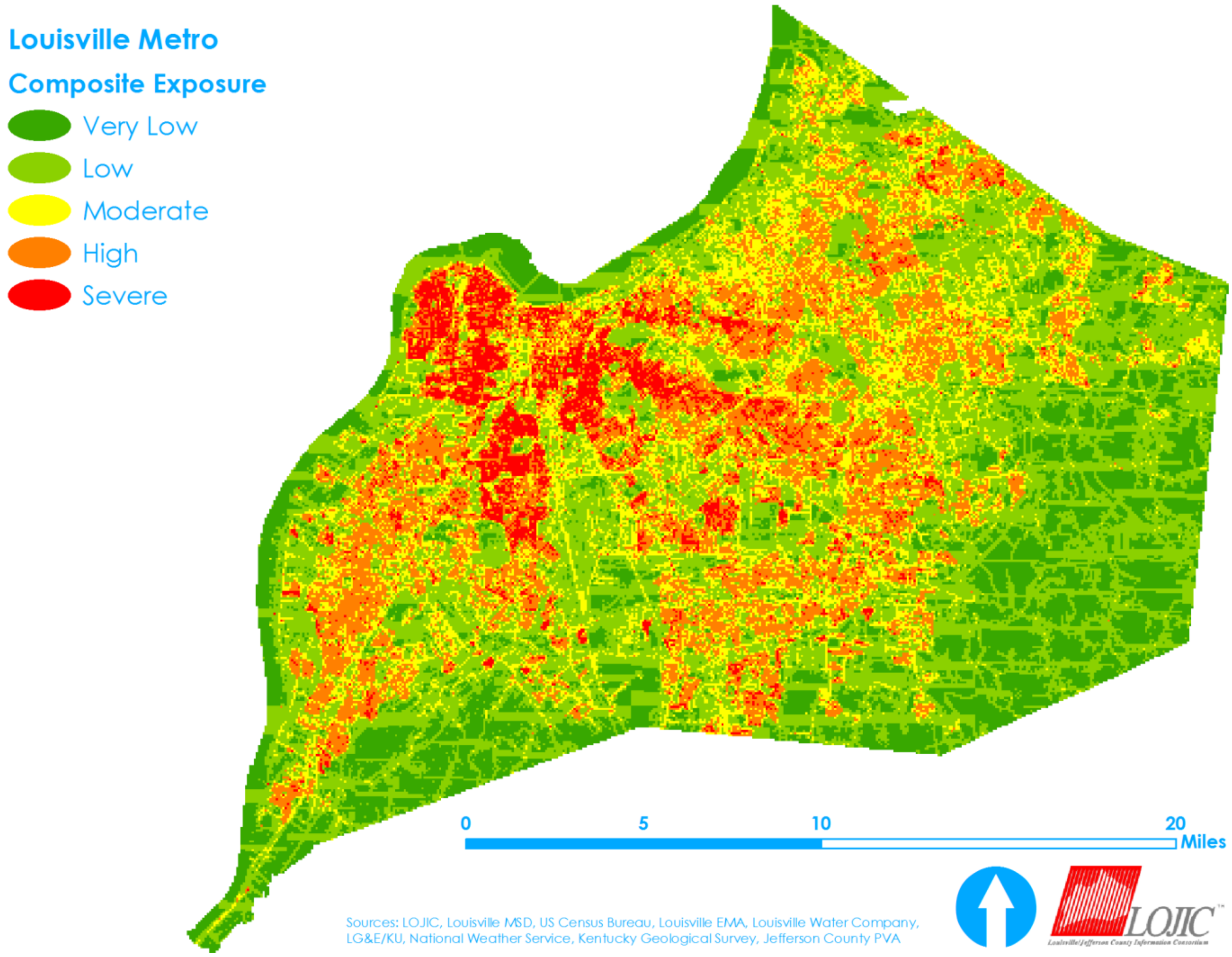
Infrastructure Types	
Drainage Pump Stations	MSD Facilities
Sewer Pump Stations	Gas Storage Facilities
Flood Pump Stations	Electrical Towers
Sewer Treatment Plants	Water Pressure Stations
Viaducts	Water Supply Lines
Sirens	Sewer Lines
Generation Facilities	Drainage Lines
LGE Facilities	Electrical Lines
Water Company Facilities	Gas Lines
Water Storage Tanks	Roads
Rail Lines	Bridges
Airports	Tunnels
Ports	Bus Depots

Exposure Score
To finalize the Exposure Score the scores for all six variables were added together and a new 0-1 score was calculated for each cell. Jenks Natural Breaks methodology was used to divide the scores into categories of Low, Moderate, High, and Severe Exposure.

The Exposure Score reveals where you have assets that could be vulnerable to a hazard. This data is critical for emergency managers and the stakeholder community to use in order to comprehend where high concentrations of need could arise during and or before a disaster. These data layers can also be used individually for multiple planning purposes. Each Exposure Score Map can be found in Appendix C.

Maps are used whenever possible to display data in a visual representation which provides the end user a comprehensive view of where there is potential Vulnerability. Figure 5 displays the composite Exposure Score.

Figure 5. Composite Exposure



4.3.1.2. Risk Score

The second variable created for the Hazard Vulnerability Score is the Risk Score. The Risk Score assigns a hazard variable to the Hazard Vulnerability Score.

Risk Score = Occurrence Score + Geographic Extent Score

Occurrence Score
The Occurrence Score includes the total number of known occurrences for each grid cell. Occurrences were counted and a 0-1 score was calculated for each cell. Occurrence data is different for each hazard and will be explained in more detail in each hazard's Assessing Vulnerability section.

(# of Occurrences - Minimum # of Occurrences)/Range

Geographic Extent Score
A Geographic Extent Score was calculated for each grid cell for each hazard, where data was available. Geographic extent was determined by either calculating the percent of the grid cell in the hazard area (flood, dam/levee, wildfire), or by assigning the identified risk level to the cell based on scientific hazard area research (karst, earthquake, landslide). Geographic Extent Scores were calculated for each grid cell and then scored on a 0-1 scale

(% affected - minimum % in affected)/Range

It is important to note, each hazards, Risk Score, is calculated based on the data available. Some hazards have an Occurrence Score and Geographic Extent Score. While others, may only have one of the Risk Score variables. The goal is to continue to capture hazard data and to create a more refined Risk Score for future plans using the 100 meter grid. Each one of the hazard's specific Risk Scores will be detailed within their Assessing Vulnerability sections.

It is important to note that the Risk Score is developed based on the representation of a hazard affecting an area, either based on past occurrences and or a scientifically based study (i.e. flood study DFIRM). This makes the Risk Score particularly useful for land use planning and future development decisions. The Hazard Vulnerability Score adds current assets (Exposure Score) to the model which is vital when dealing with emergency management planning issues. This is pointed out to display the multiple uses of the data created during this process.

4.3.1.3. Vulnerability Score

After the Exposure Score and the Risk Score were determined, a Hazard Vulnerability Score was calculated for each hazard. The two scores were added together and a new 0-1 score was calculated for each cell. Where cells had a Risk Score of zero (0) the vulnerability score was also zero. This score reflects the combination of exposure and risk, so cells with high levels of exposure combined with high levels of risk will have a high level of vulnerability. Alternatively, cells with a low level of exposure and a low level of risk will have a low level of vulnerability.

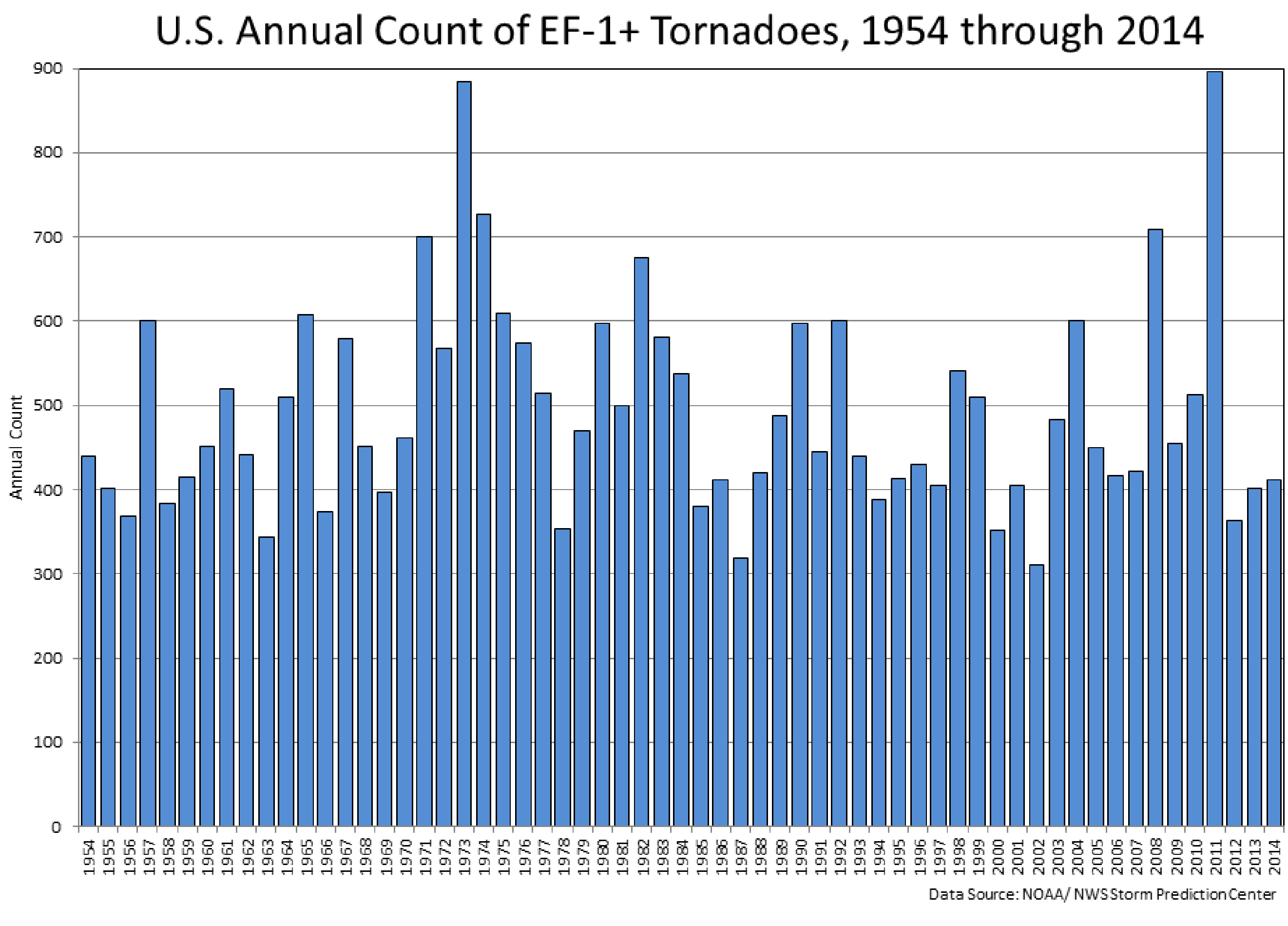
The Hazard Vulnerability Scores may appear to contain some bias toward the more populated areas in the county. This is due to a correlation between density of population and density of infrastructure, properties, and critical facilities. This resulted in densely populated areas having greater exposure in general. The goal of this model was to assess the most vulnerable areas throughout Louisville Metro. Given the most populated areas have the most at risk, this model achieved that goal.

4.4. Tornado

4.4.1.Identify: Tornado

A tornado is a violent windstorm characterized by a twisting, funnel-shaped cloud extending to the ground. It is spawned by a thunderstorm (or sometimes as a result of a hurricane) and produced when cool air overrides a layer of warm air, forcing the warm air to rise rapidly.

The damage from a tornado is a result of the high wind velocity and wind-blown debris with paths that can be in excess of one mile wide and fifty miles long. Tornado season is generally March through August, although tornadoes can occur at any time of year. They tend to occur in the afternoons and evenings; over 80 percent of all tornadoes strike between noon and midnight.



Most tornadoes are just a few dozen yards wide and touch down only briefly, but highly destructive tornadoes may carve out a path over a mile wide and several miles long. The destruction caused by tornadoes may range from light to catastrophic depending on the intensity, size, and duration of the storm. Effects of tornadoes may include crop and property damage, power outages, environmental degradation, injury, and death. Tornadoes are known to blow off roofs, move cars and tractor-trailers, and demolish homes.

Typically, tornadoes are localized in impact and cause the greatest damages to structures of light construction, such as residential homes. A tornado can move as fast as 125 mph with internal winds speeds exceeding 300 mph.

Tornado Types

The magnitude of a tornado is categorized by the damage pattern (i.e. path) and wind velocity, according to the Fujita-Pearson Tornado Measurement Scale. This scale is the only widely used rating method with the aim to validate classification by relating the degree of damage to the intensity of the wind.

Enhanced F Scale for Tornado Damage

Following is an update to the Original F-Scale by a team of meteorologists and wind engineers, to be implemented 1 February 2007.

Fujita Scale			Derived EF Scale		Operational EF Scale	
F Number	Fastest 1/4-mile (mph)	3 Second Gust (mph)	EF Number	3 Second Gust (mph)	**EF Number**	**3 Second Gust (mph)**
0	40-72	45-78	0	65-85	**0**	**65-85**
1	73-112	79-117	1	86-109	**1**	**86-110**
2	113-157	118-161	2	110-137	**2**	**111-135**
3	158-207	162-209	3	138-167	**3**	**136-165**
4	208-260	210-261	4	168-199	**4**	**166-200**
5	261-318	262-317	5	200-234	**5**	**Over 200**

*** IMPORTANT NOTE ABOUT ENHANCED F-SCALE WINDS: The Enhanced F-scale still is a set of wind estimates (not measurements) based on damage. Its uses three-second gusts estimated at the point of damage based on a judgment of 8 levels of damage to the 28 indicators listed below. These estimates vary with height and exposure. Important: The 3 second gust is not the same wind as in standard surface observations. Standard measurements are taken by weather stations in open exposures, using a directly measured, "one minute mile" speed.

4.4.2. Profile: Tornado

Profile Risk Table	
Period of occurrence:	Year-round, primarily during March through August. The month of May normally experiencing the greatest number of tornadoes.
Number of events:	23 (1964-2016)
Probability of events:	.46
Past Damages	$5,705,000
Warning time:	Minutes to hours. Over 80 % of all tornadoes strike between noon and midnight.
Potential impact:	Utility damage and outages, infrastructure damage (transportation and communication systems), structural damage, and damaged or destroyed critical facilities. Impacts human life, health, and public safety.
Potential of injury or death:	Tornadoes have a high potential to cause death.
Possible Extent:	April 3, 1974 - 3 fatalities and 225 injuries, over 900 homes destroyed

The occurrence of a Kentucky tornado is predictable because a tornado touches down somewhere in Kentucky every year. Kentucky is located in the most severe wind zone (ZONE IV 250 mph) in the country. This signifies that most of the state is highly vulnerable to tornadic weather. Tornadoes are somewhat common throughout Kentucky and have occurred in every month of the year. Conversely, the occurrence of a tornado is highly unpredictable because it is impossible to forecast the exact time and location that it will touch down and the path that it will take.

Most tornadoes occur between March and July, with the month of May normally experiencing the greatest number of tornadoes. The strongest tornadoes, which usually result in the highest number of deaths and greatest destruction of property, occur between April and June. Most deaths occur in April, which is considered the beginning of the tornado season.

Tornado Potential Impact

Due to the destructive nature of tornadoes and wind, these events impact human life, health, and public safety. Community-wide impacts include: utility damage and outages, infrastructure damage (transportation and communication systems), structural damage, and damaged or destroyed critical facilities. Tornadoes can also cause severe transportation problems and make travel extremely dangerous.

Louisville Metro Tornado History

In Louisville Metro tornadoes have occurred in 1890, 1917, 1925, 1928, 1964, 1969, 1974, 2006, and 2008. Injuries, damages, and fatalities attributed to tornadoes have also been on the increase in recent years. In 1971 there were nine deaths and some 130 injuries from tornadoes. In 1974 there were 76 tornado fatalities and approximately 1,000 personal injuries from the exceptionally high number of tornadoes that affected the state that year. (LMEOP). One tornado event has been Presidentially declared for Louisville Metro, as shown in this table.

April 3, 1974

An F4 tornado touched down in Louisville near the Fairgrounds and continued for approximately 14.2 miles through northeaster Louisville. Three people were killed and at least 225 were injured. The tornado destroyed over 900 homes.

April 22, 2005
The tornado first touched down near the intersection of Campbell and Market Streets, where the roof on a business was destroyed, and a telephone pole was snapped. An empty trailer was flipped over near this location. The Stockyard Farm Supply Company on South Johnson Street sustained roof damage.

January 2, 2006
A tornado touched down at the corner of Bramers and Campground Road in western Louisville Metro. Many homes along the damage path had roof damage. Numerous trees and power lines were downed; one tree was blown on to a house. The local Moose Lodge building had significant damage.

October 18, 2007
The EF-0 tornado touched down briefly at a grocery store at 2200 Brownsboro Road. A cold front with strong upper level support collided with a very moist air mass over the lower Ohio Valley. The result was a widespread outbreak of severe thunderstorms, and six confirmed tornadoes. The storms produced property damage, downed trees and power lines, and large hail.

January, 29 2008
A fast moving EF-1 tornado briefly touched down four times in the Louisville Metro area as a squall line crossed the city. The tornado was on the ground for approximately 1.5 miles over the course of its 16-mile long track. The first touchdown was in and industrial area just off Millers Lane west of the Dixie Highway. The tornado stayed on the ground for one mile before lifting, heavily damaging a church on Dixie Highway, as well as uprooting and snapping several trees and damaging numerous homes. The tornado then dipped again on the west side of the University of Louisville campus, breaking out many windows and damaging several vehicles. The next touchdown in St. Matthews near the intersection of Shelbyville Road and Interstate 264, caused extensive damage to many businesses and private properties. The fourth and final touchdown was in Anchorage where trees were damaged, blown over, and uprooted, roofs were damaged, and a large outbuilding at a training school was destroyed. A large number of locations had 60 to as much as 100 mph winds, causing extensive property damage. There were also a few small tornado spin-ups.

June 22, 2011
Although this did not end up being a Presidentially declared disaster, a series of tornadoes and high winds struck Louisville on June 22, 2011, including two EF-2. One EF2 caused significant damage to Churchill downs and around the UofL campus. The second EF2 tornado touched down in Jeffersontown damaging several industrial and warehousing facilities. The storm also include scattered instances of flash flooding

4.4.3. Assessing Vulnerability: Tornado

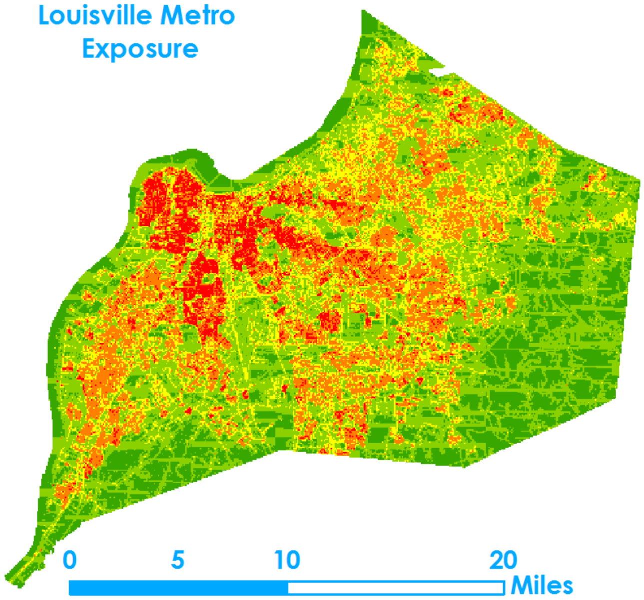
Tornado Vulnerability Score = Exposure Score + Risk Score

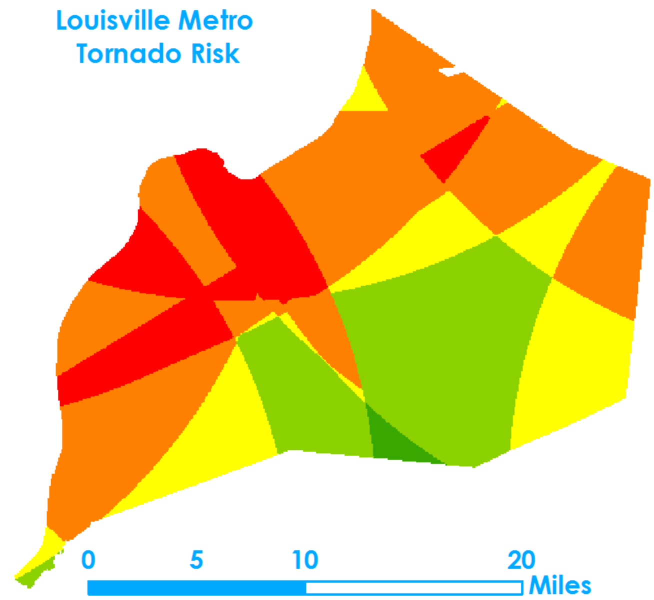
Risk Score = Occurrences

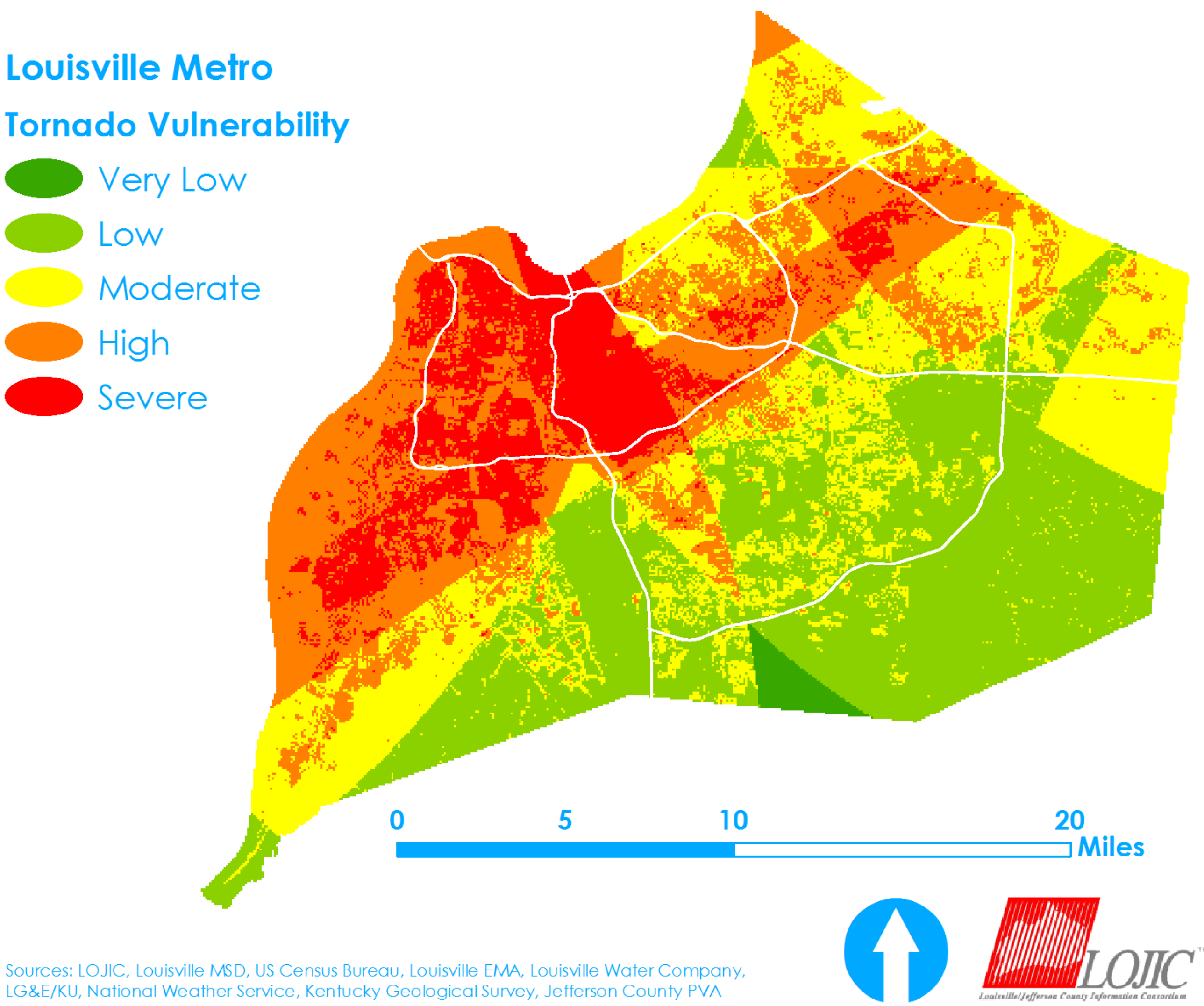
Occurrences = Occurrences were calculated for each grid cell by identifying and counting all tornado events/tracks within 25 miles of each cell. Tornado events included were all recorded tornadoes from 1950 – 2015 (NOAA Storm Prediction Center).

The Tornado Risk Score and the Exposure score were added together and a new 0-1 score was calculated to give the final Tornado Vulnerability Score (Figure 6).

Figure 6. Tornado Hazard Vulnerability Map







Sources: LOJIC, Louisville MSD, US Census Bureau, Louisville EMA, Louisville Water Company, LG&E/KU, National Weather Service, Kentucky Geological Survey, Jefferson County PVA

4.5. Severe Winter Storm

4.5.1. Identify: Severe Winter Storm

A winter storm can range from moderate snow over a few hours to blizzard conditions with blinding wind-driven snow, sleet and/or ice and extreme cold that lasts several days.
A severe winter storm is defined as an event that drops four or more inches of snow during a 12-hour period or six or more inches during a 24-hour span. Severe winter storms are fueled by strong temperature gradients and an active upper-level cold jet stream. Some winter storms may be large enough to affect several states while others may affect only a single community. Most winter storms are accompanied by low temperatures and blowing snow, which can severely reduce visibility.

Snow and ice are threats to most of the U. S. during the northern hemisphere's winter, which begins December and ends in Spring. During the early and late months of the winter season, snow becomes warmer, giving it a greater tendency to melt on contact or stick to the surface. The beginning and end of the winter season also brings a greater chance of freezing rain and sleet.

Severe Winter Types

- Blizzards are by far the most dangerous of all winter storms. They are characterized by temperatures below twenty degrees Fahrenheit and winds of at least 35 miles per hour. In addition to the temperatures and winds, a blizzard must have a sufficient amount of falling or blowing snow. The snow must reduce visibility to one-quarter mile or less for at least three hours. With high winds and heavy snow, these storms can punish residents throughout much of the U.S. during the winter months each year. In mid-March of 1993, a major blizzard struck the Eastern U.S., including parts of Kentucky.
- Ice storms occur when freezing rain falls from clouds and freezes immediately on impact. Ice storms occur when cold air at the surface is overridden by warm, moist air at higher altitudes. As the warm air advances and is lifted over the cold air, precipitation begins falling as rain at high altitudes then becomes super cooled as it passes through the cold air mass below, and, in turn, freezes upon contact with chilled surfaces at temperatures of 32° F or below. In extreme cases, ice may accumulate several inches thick, though just a thin coating is often enough to do severe damage.

Possible Effects

Freezing rain can result in extensive damage to utility lines and buildings while making any type of travel extremely dangerous. The results are sometimes devastating: entire states can be almost entirely without electricity and communication for several weeks. Winter storms can paralyze a community by shutting down normal day-to-day operations. Heavy snow can also lead to the collapse of weak roofs or unstable structures. Storm effects can cause hazardous conditions and hidden problems, including the following:

- Power outages result when snow and ice accumulate on trees causing branches and trunks to break and fall onto power lines. Blackouts vary in size from one street to an entire city. Loss of electric power means loss of heat for some residents, which poses a significant threat to human life, particularly the elderly.
- Flooding may occur after precipitation has accumulated and then temperatures rise once again, which melts snow and ice. In turn, as more snow and ice accumulate the threat of flooding increases.

- Snow and ice accumulation on roadways can cause severe transportation problems in the form of extremely hazardous roadway conditions.
- Extreme cold temperatures may lead to frozen water mains and pipes, damaged car engines, and prolonged exposure to cold resulting in frostbite.

Everyone is potentially at risk during winter storms. In terms of death due to severe winter storms, 70% of the deaths are related to automobile accidents. 25% of those deaths occur when people are caught out in the storm and die from exposure. Of all the deaths related to exposure to cold, 20% occur at home.

4.5.2. Profile: Severe Winter Storm

Profile Risk Table	
Period of occurrence:	Winter
Number of events:	27 (1996-2013)
Probability of events:	1.35
Past Damages	$105,000
Warning time:	Days for snow Minutes to hours for ice.
Potential impact:	Utility damage and outages, infrastructure damage (transportation and communication systems), structural damage, and damaged or destroyed critical facilities Can cause severe transportation problems and make travel extremely dangerous. Power outages, which results in loss of electrical power and potentially loss of heat, and human life. Extreme cold temperatures may lead to frozen water mains and pipes, damaged car engines, and prolonged exposure to cold resulting in frostbite.
Potential of injury or death:	Severe Winter Storms have a moderate potential for injury or death.
Possible Extent:	2009 Ice Storm – Over 10 inches of snow and ice accumulation, over 400,000 people lost power, some for up to 10 days, nearly $8.5 million in FEMA Project Worksheets

Kentucky's location makes it vulnerable to heavy snowfall due to the state's proximity to the Gulf of Mexico, which provides a necessary moisture source, yet it is far enough north to be influenced by polar air masses. Low-pressure systems that bring heavy snow to Kentucky usually track eastward across the southern U.S. before turning toward the northeast. Frequently, these systems move up the east coast and have little effect on Kentucky. Sometimes, however, storms turn and move along the western margin of the Appalachian Mountains. With cold air in place over Kentucky, these storms bring moisture from the Gulf of Mexico and can dump heavy snow. During 1993- 2009, Kentucky received 7 Presidential Disaster Declarations due to severe winter weather. Table 8 depicts normal snowfall for Louisville.

Table 8. Normal Snowfall

Month	Louisville Metro Normal Snowfall
January	3.7"
February	4.5"
March	1.4"
April	0.0"
May	0
June	0
July	0
August	0
September	0
October	0.1"
November	0.1"
December	2.6"
Annual	**12.5"**
Source: http://www.weather.gov/lmk/clisdf	

Potential Impact to Louisville Metro

Due to the destructive nature of snow and ice these events impact human life, health, and public safety. Community-wide impacts include: power outages, which results in loss of electrical power and potentially loss of heat, and human life. Extreme cold temperatures may lead to frozen water mains and pipes, damaged car engines, and prolonged exposure to cold resulting in frostbite. Community-wide impacts include: Utility damage and outages, infrastructure damage (transportation and communication systems), structural damage, and damaged or destroyed critical facilities. Can cause severe transportation problems and make travel extremely dangerous.

Historical Impact

The level of impact severe winter weather will have upon a community greatly depends on its ability to manage and control its effects, such as the rapid mobilization of snow removal equipment. Louisville Metro has experienced several crippling winter storms over the years, which is common to the region due to its geographical location. It is expensive to acquire and maintain the necessary resources to combat winter's effects such as generators, snow removal equipment, and trucks. Preparedness includes, planning for emergency shelters and power outages.

Following is a table showing the Presidentially declared snow event in Louisville Metro.

Disaster Number	Declaration Date	Disaster Type	# of KY Declared Counties
1089	1/13/1996	Blizzard	120
1818	2/15/09	Severe Winter Storm and Flooding	103

Louisville Metro Historic Snow Events:

February 11, 2008
Four inches of snow fell the evening of the 11th. 1/4 inch of ice early on the 12th glazed roads and brought about minor tree damage. Tree branches falling on power lines bought about a power outage to 4000 residents in the Louisville metropolitan area. Snow developed during the late afternoon on February 11th and continued until late evening. A swath of 3 to 4 inch accumulations fell across Hancock...Northern Breckenridge...Meade and Jefferson counties eastward along interstate 64 through the northern Bluegrass region. Freezing rain later developed across northern Kentucky during the pre-dawn hours on February 12th. Ice accumulations ranging from 1/4 of an inch to just under 1/2 of an inch were common until temperatures rose above freezing by late morning. Ice accumulations brought minor tree damage. The snow and freezing rain lead to numerous school and activity cancellations.

March 7, 2008
A snowstorm developed during the early morning hours Friday March 7th. Snow and some sleet fell intermittently over the next 28 hours. Snowfall totals were highest along the Ohio River, where accumulations varied from 10 to 12 inches. Farther south...snow started later in the day and accumulations were lower. Snow totals varied widely across the Bluegrass region, ranging from 8 inches in Frankfort to less than 4 inches south and east of Lexington. Sleet with occasional thunder fell across the eastern Bluegrass region late on the 7th...with 1 to 2 inches of sleet accumulating. Across south central Kentucky, snowfall ranged from over 8 inches north of Bowling green to just under 4 inches along the Kentucky-Tennessee border.

December 23, 2008
Slick roads due to light freezing rain lead to several injury-causing accidents and one fatality in the Louisville metropolitan area. The fatality occurred when a driver lost control of his vehicle and in eastern Louisville Metro. Another accident on the Gene Snyder Expressway injured two emergency workers who were providing aid to a driver hurt in an earlier crash. The three were taken to University Hospital with injuries that did not appear to be life-threatening. Emergency workers in Louisville responded to as many as 40 calls about accidents between 2 and 5 p.m. due to the icy conditions. Light freezing rain developed during the afternoon of December 23rd. Ice accumulation on roads across the northern portions of Kentucky lead to numerous traffic accidents and several fatalities.

January 26-28, 2009
Historic Ice Storm on January 26, 2009 the storm began with snow which changed to freezing rain. Up to 6 inches of snow accumulated. Freezing rain continued over southern Kentucky. On Tuesday the 27th, precipitation changed to freezing rain over southern Indiana and northern Kentucky and to rain over southern Kentucky. Ice over an inch thick was reported in many locations from the freezing rain. Tuesday night freezing rain and sleet continued over southern Indiana, freezing rain transitioned to rain over northern Kentucky, and rain, occasionally heavy, continued over southern Kentucky. Minor river flooding developed in some spots by Wednesday from the steady rain. On the morning of Wednesday, January 28, precipitation changed over to snow from northwest to southeast across the area. About 3 to 4 inches of additional snow accumulation piled up in the north, with less to the south.

This was followed on **February 3-5** with 20 mph wind gusts and subzero temperatures. By storm's end, there was a snow accumulation 2 to 10 inches and statewide power outages of more than 769,000. In Louisville Metro there were power outages for 404,000 people.

Governor Steve Beshear called the storm the 'Worst natural disaster in the history of Kentucky'. On January 29, 2009, President Obama announced an Emergency Declaration for Kentucky. In total, 101 out of 120 counties were declared a state of emergency and the President issued a Presidential Disaster Declaration on February 5 (DR 1818).

KyEM and FEMA estimated damage at more than $214 million. Kentucky issued the first ever call-up of Kentucky National Guard with 4,100 personnel/troops. The storm caused Kentucky's worst death toll with 36 storm-related deaths. A Partnership between KyEM and USACE resulted in the largest emergency generator placement of 160.

The affect on the power system surpassed all aspects of the Ike windstorm just five months earlier. The storm caused Kentucky's largest power outage on record, with 609,000 homes and businesses without power across the state. Property damage was widespread, with the damage due to falling trees, large tree limbs, and power lines weighed down by ice.

In the Louisville metropolitan area, 205,000 lost power and it took up to 10 days to get the power restored. Area school systems were closed for an entire week. Several emergency shelters were set up across the affected region. In Louisville's local school system, 69 schools lost power.

Following is the summary of Project Worksheets submitted due to DR 1818 – Ice Storm

- Total Eligible Applicants – 66, Total Projects (PWs) 178
  - Category A - $5,225,398.20 /PWs = 62
  - Category B - $3,135,102.32 /PWs = 81
  - Category C - $51,751.00 /PWs = 2
  - Category D - $0 /PWs = 0
  - Category E - $42,324.20 /PWs = 21
  - Category F - $18,844.38 /PWs = 2
  - Category G - $16,324.57 /PWs = 43
- Total Project Amount -$8,489,744.67

January 7, 2010

Three to four inches of snow fell countywide. Officially, 3 inches were measured by observers at Standiford Field in Louisville. The local newspaper reported very slick roads and numerous traffic accidents. An upper level trough and a weak surface low moved across central Indiana during the day. Snow began near dawn and continued on an intermittent basis through late afternoon. Snow accumulations ranged from 3 to 4 inches across the northern Bluegrass Region and areas adjacent to the Ohio River, to around 1 inch near the Tennessee border. Precipitation remained all snow despite the northerly track of the surface low and light southerly winds. Due to antecedent cold temperatures, snow accumulated readily on roads and bridges, causing many accidents and travel problems.

January 29, 2010

Officially, 3.6 inches of snow fell at the Louisville International Airport. Four and one half inches of snow fell at the NWS forecast office. Traffic was severely hampered early Saturday morning. An upper level disturbance moved east from the southern plains through the Tennessee Valley late on a Friday night. This storm spread a broad swath of heavy snow extending from Oklahoma eastward across the Tennessee Valley and across the southern Appalachians through the Mid-Atlantic States. Snow slowly moved northeast into south central Kentucky by mid-afternoon Friday, January 29th. Light to moderate snow continued across central Kentucky before ending shortly after dawn on Saturday. Due to antecedent dry air, snow did not develop across north central Kentucky and the Bluegrass Region until late Friday evening. Four to 8 inches of snow fell across the southern tier of counties adjacent to Tennessee. This amount of snow had not been seen in this area for several years. Farther north, 4 to 6 inches of snow fell across central Kentucky along and south of a line from Louisville through Lexington. Other locations along the Ohio River northeast of Louisville and across the northern Bluegrass received 1 to 4 inches.

February 8, 2010

Just over 6 inches of snow fell at Standiford Field (Louisville International Airport) in Louisville. 6.3 inches was measured at the National Weather Service Forecast Office. An inverted trough moving across Tennessee combined with an upper low sliding south across the upper Midwest brought a mixture of heavy snow, sleet and rain across central Kentucky Tuesday morning February 9th. Snow began during the evening hours across south central Kentucky and moved north of Interstate 64 by midnight. By the early morning hours, snow had turned to sleet and rain south and east of a line from Breckinridge County through Henry County. Along the Ohio River, banded precipitation brought intermittent bursts of heavy snow around 8 to 9 am. The heaviest snow totals fell along the Ohio River, where 4 to 7 inches of accumulation were common. Sleet and rain limited snowfall amounts to 1 to 3 inches across south central Kentucky and the Bluegrass Region.

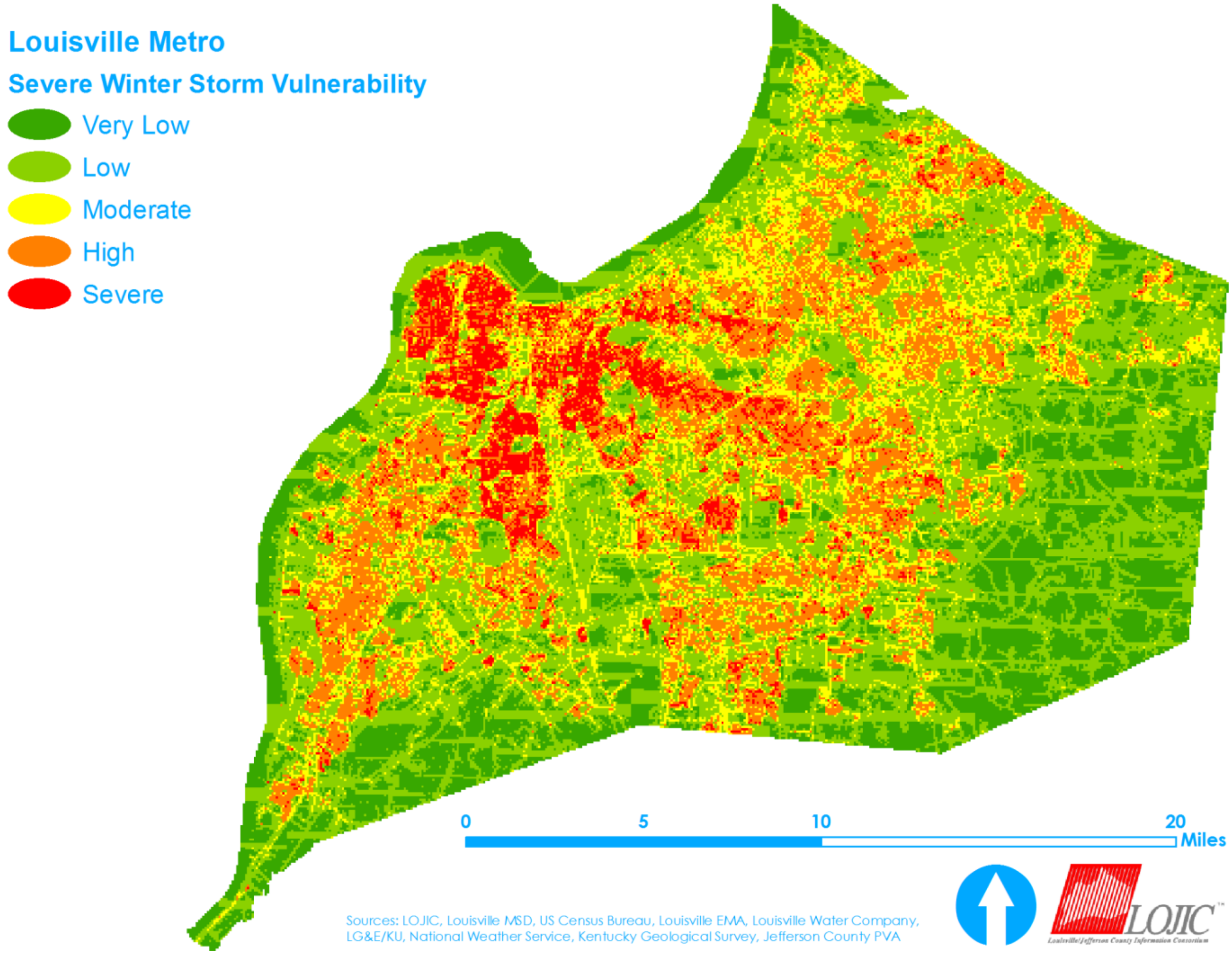
4.5.3. Assessing Vulnerability: Severe Winter Storm

Severe Winter Storm Vulnerability Score = Exposure Score + Risk Score

The Severe Winter Storm Vulnerability Score is currently difficult to calculate. Currently Louisville Metro has no real spatial data that can be calculated to determine vulnerable areas to Severe Winter Storm. Severe Winter Storm is the type of hazard that typically affects a county the size of Louisville Metro equally. With that being said it was determined to use the Exposure Score map to display the Severe Winter Storm Vulnerability Score based on the assumption that the entire county is equally vulnerable to Severe Winter Storm.

The Exposure Score provides a visual display of areas that could be harder hit by winter storms based on the exposure that is within each grid cell (Figure 7).

Figure 7. Severe Winter Storm Hazard Vulnerability Map



4.6. Severe Storm

4.6.1. Identify: Severe Storm

A thunderstorm is formed from a combination of moisture, rapidly rising warm air, and a force capable of lifting air such as a warm and cold front, a sea breeze or a mountain. All thunderstorms contain lightning and may occur singly, in clusters or in lines. Thus, it is possible for several thunderstorms to affect one location in the course of a few hours. Some of the most severe weather occurs when a single thunderstorm affects one location for an extended period time. The NWS considers a thunderstorm as severe if it develops ¾ inch hail or 50-knot (58 mph) winds.

Lightning is an electrical discharge that results from the buildup of positive and negative charges within a thunderstorm. When the buildup becomes strong enough, lightning appears as a "bolt". This flash of light usually occurs within the clouds or between the clouds and the ground. A bolt of lightning reaches a temperature approaching 50,000 degrees Fahrenheit in a split second. The rapid heating and cooling of air near the lightning causes thunder.

Additional types of severe storms include straight line winds. There are several terms that mean the same as straight-line winds and they are convective wind gusts, outflow and downbursts. Straight-line wind is wind that comes out of a thunderstorm. If these winds meet or exceed 58 miles per hours then the storm is classified as severe by the National Weather Service. These winds are produced by the downward momentum in the downdraft region of a thunderstorm. Radar observers use the intensity of the radar echo to distinguish between rain showers and thunderstorms. Lightning detection networks routinely track cloud-to-ground flashes, and therefore thunderstorms.

Thunderstorms occur when clouds develop sufficient upward motion and are cold enough to provide the ingredients (ice and super cooled water) to generate and separate electrical charges within the cloud. The cumulonimbus cloud is the perfect lightning and thunder factory, earning its nickname, "thunderhead".

All thunderstorms are dangerous and capable of threatening life and property in localized areas. While thunderstorms and lightning can be found throughout the U. S., they are most likely to occur in the central and southern states. Thunderstorms can also produce large, damaging hail, which causes nearly $1 billion in damage to property and crops annually. Thunderstorms are also capable of producing tornadoes, wind, and heavy rain that can lead to flash flooding. Hail, floods, and tornado hazards are addressed as individual hazards in this section of the Plan.

Types of Thunderstorms

- Single Cell (pulse storms). Typically last 20-30 minutes. Pulse storms can produce severe weather elements such as downbursts, hail, some heavy rainfall, and occasionally weak tornadoes. This storm is light to moderately dangerous to the public and moderately to highly dangerous to aviation.
- Multicell Cluster. These storms consist of a cluster of storms in varying stages of development. Multicell storms can produce moderate size hail, flash floods, and weak tornadoes. This storm is moderately dangerous to the public and moderately to highly dangerous to aviation.
- Multicell Line. Multicell line storms consist of a line of storms with a continuous, well-developed gust front at the leading edge of the line. Also known as squall lines, these

storms can produce small to moderate size hail, occasional flash floods, and weak tornadoes. This storm is moderately dangerous to the public and moderately to highly dangerous to aviation.

- Supercell. Even though it is the rarest of storm types, the supercell is the most dangerous because of the extreme weather generated. Defined as a thunderstorm with a rotating updraft, these storms can produce strong downbursts, large hail, occasional flash floods, and weak to violent tornadoes. This storm is extremely dangerous to the public and aviation.
- Straight-line winds, which in extreme cases have the potential to exceed 100 miles per hour, are responsible for most thunderstorm wind damage. One type of straight-line wind, the downburst, can cause damage equivalent to a strong tornado and can be extremely dangerous to aviation.

4.6.2. Profile: Severe Storm

Profile Risk Table	
Period of occurrence:	Spring, Summer and Fall
Number of events:	452 (1957-2015)
Probability of events:	7.66
Past Damages	$3,552,000
Warning time:	Minutes to hours
Potential impact:	Utility damage and outages, infrastructure damage (transportation and communication systems), structural damage, fire, damaged or destroyed critical facilities, and hazardous material releases. Impacts human life, health, and public safety.
Potential of injury or death:	Severe Storms have a moderate potential for injury or death.
Possible Extent:	2008 - Remnants of Hurricane Ike caused power outages for over 300,000 people, tore down over 1300 power lines, blocked 130 roads, and resulted in over $6.6 million in FEMA Project Worksheets.

The Midwest and Great Plains regions of the U.S. average between 40 and 60 days of thunderstorms per year. These two regions are prone to some of the most severe thunderstorms on Earth. Lightning is a component of all thunderstorms. Flashes that do not strike the surface are called cloud flashes. They may be inside a cloud, travel from one part of a cloud to another, or from cloud to air. Lightning flashes can have more than one ground point. Roughly, there are five to ten times as many cloud flashes than cloud to ground flashes. Overall, there are four different types of lightning:

- Cloud to sky (sprites)
- Cloud to ground
- Intra-cloud
- Inter-cloud

Cloud to ground lightning can injure or kill people and destroy objects by direct or indirect means. Objects can either absorb or transmit energy. The absorbed energy can cause the object to explode, burn, or totally destruct.

The various forms of transfer are:

- Tall object transferred to person
- Tall object to ground to person
- Object (telephone line, plumbing pipes) to a person in contact with the appliance

Potential Impacts of Severe Storms

Due to the destructive nature of thunderstorms and lightning these events impact human life, health, and public safety. The community is at-risk for: utility damage and outages, infrastructure damage (transportation and communication systems), structural damage, fire, damaged or destroyed critical facilities, and hazardous material releases.

Louisville Metro Severe Storm History

Louisville Metro has received six presidential declarations for severe storms.

Disaster Number	Declaration Date	Disaster Type	# of KY Declared Counties
568	12/12/1978	Severe Storms, Flooding	37
821	2/24/1989	Severe Storms, Flooding	67
1471	6/3/2003	Landslide, Severe Storm, Tornado, Flooding	44
1523	6/10/04	Severe Storms, Tornadoes, Flooding, and Mudslides	78
1802	10/09/08	Severe Wind Storm Associated With Tropical Depression Ike	34
1855	08/14/09	Severe Storms, Straight-Line Winds, And Flooding	2

Between 2005 – 2010 there were 69 severe storms according to NCDC results. No deaths or injuries were reported during this time period. Fourteen storms caused property damage, ranging from $5 - 50K. Only one storm caused property damage of $50K. A narrative for this event is outlined below.

April 3, 2007

A tree was blown on to a house on Algonquin Parkway. Power lines were downed and a house suffered some roof damage near the intersection of Sixth Street and St. Catherine. A strong, late season cold front brought an end to an extended period of warm weather. It also brought severe storms to central Kentucky, including two confirmed tornadoes. $50K reported in Property Damage.

September 2008:

DR-1802-14 - The largest severe windstorm since the 1974 tornado caused by a Tropical Depression from Hurricane Ike hit the area with 80-mile an hour winds and effecting 1.8 million residents. Major Disaster Declaration number DR 1802 was declared on October 09, 2008. The impacts of the storm included extended power outages and extensive damage to trees and roofs.

The impact to the electric distribution system was unprecedented in the area. In the Louisville area, 301,000 people lost power, which was a new record for the city. 1400 power lines were torn

down, hundreds of power poles snapped, and 130 roads blocked by debris. Four people were killed by falling trees and limbs in Kentucky.
Below are the damage estimates from DR 1802 - Wind in Louisville.

Total Eligible Applicants - 55

Total Projects (Project Worksheets) 138

- Category A - $4,492,356.71 /PWs = 43
- Category B - $1,494,405.96 /PWs = 41
- Category C - $167,363.58 /PWs = 1
- Category D - $0 /PWs = 0
- Category E - $426,596.70 /PWs = 40
- Category F - $2,139.64 /PWs = 2
- Category G - $46,189.99 /PWs = 11

Total Project Amount: $6,629.052.58

May 2009
DR-1841-20 - Starting on May 3, 2009, strong storms producing tornadoes, severe thunderstorms, heavy rainfall, flash flooding, and generalized flooding moved across the central and eastern parts of the Commonwealth resulting loss of life and private property and road closures and these conditions endangered public health and safety and threatened public and private property. There were over half a million citizens impacted by this event. FEMA estimates that total public assistance for this event will exceed $44 million. Over 5,543 applicants in four counties were awarded approximately $15 million in individual and household assistance.

August 2009
DR-1855-14 - The counties of Jefferson and Trimble experienced a severe storm which contained straight-line winds and flooding. The flooding in Louisville was centralized in the downtown resulting in significant damages to the University of Louisville, the Louisville Public Library, several hospitals, and over a thousand private residences. Public Assistance is estimated to exceed $27 million dollars and over $17 million has been distributed in individual and household assistance.

May 19, 2005
2 events: Widespread reports of large hail, and a few more reports of non-severe hail in other locations. Flooding of low-lying areas, and streams flowing out of banks, also resulted from thunderstorms. A lightning strike caused a house fire on Waters Edge Drive. Property damage was estimated at $10K. A lightning strike caused a house fire on Pepperdine Court. Property Damage was estimated at $10K.

May 25, 2004
2 events: A house fire started due to a lightning strike in the 6700 block of Green Manor Drive. Details of damage were unavailable. Property Damage was estimated at $10K. Lightning blew a three foot hole in the side of a house. Fire caused moderate damage to the second floor and attic of the house. Property Damage was estimated at $20K.

May 27, 2004
A tree was struck by lightning and fell on a car, destroying it. Property Damage was estimated at $10K

June 27, 2007

Two houses were struck by lightning, and had attic damage due to fire. A weak upper level disturbance pushed some pulse thunderstorms above severe limits. Property Damage was estimated at $20K.

August 16, 2007
Lightning started a house fire in the Jeffersontown area. The extent of damage is unknown. Property Damage was estimated at $10K.

July 8, 2008
Lightning started a large house fire in the Lake Forest area. Two lines of thunderstorms brought damaging winds and small hail to the area. Lightning also caused a house fire. Property Damage was estimated at $74K.

June 18, 2009
Lightning struck two houses in the Jeffersontown area and caused several structural fires across the county. While damaging winds were the main event, some hail and lightning strikes causing fires were also reported. Property Damage was estimated at $15K.

August 4, 2009
Lightning started a four alarm apartment fire on Hurstbourne Parkway near I-64. Property Damage was estimated at $ 200K.

4.6.3. Assessing Vulnerability: Severe Storm

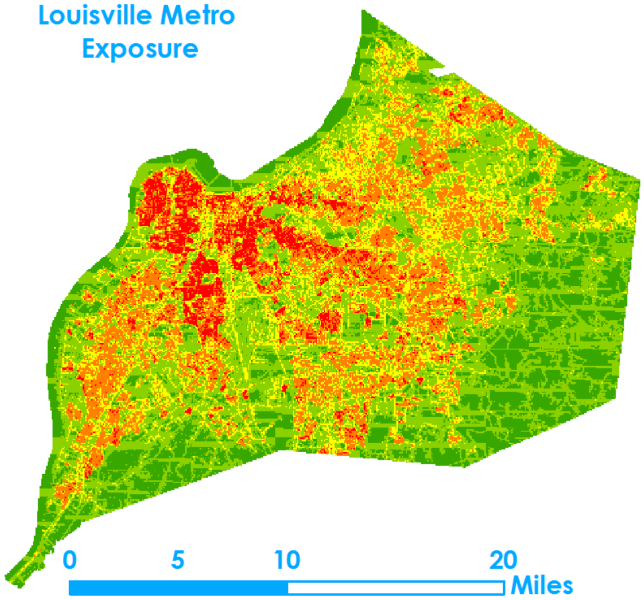
Severe Storm Vulnerability Score = Exposure Score + Risk Score

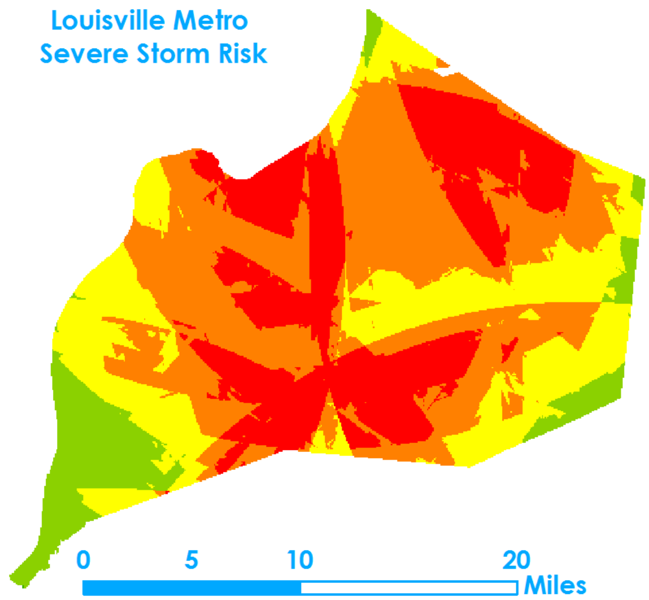
Risk Score = Occurrence Score

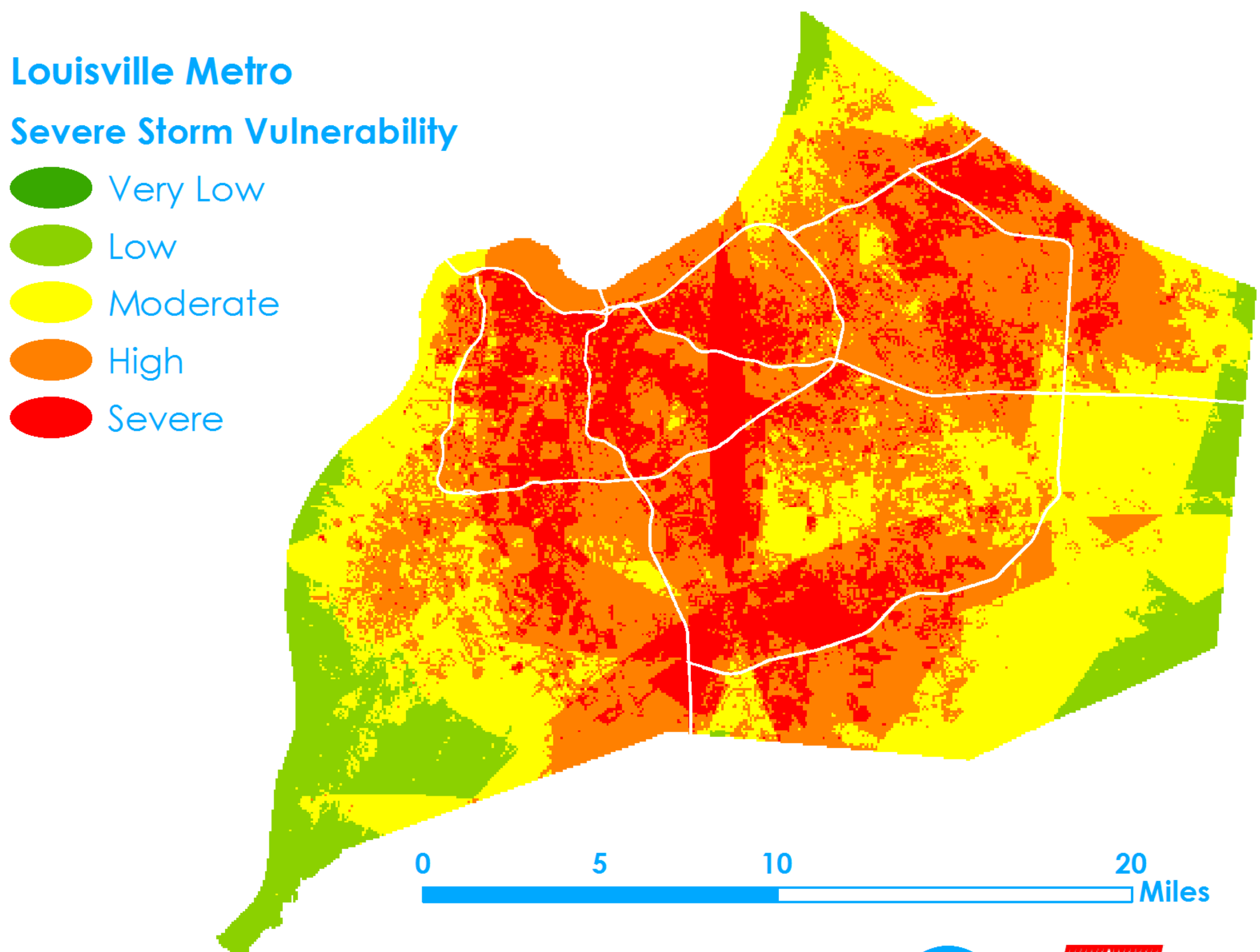
Occurrences = Occurrences were calculated for each grid cell by identifying and counting all Severe Storm events within 25 miles of each cell. Severe Storm events included were all recorded thunderstorm and wind events from 1950 – 2015 (National Centers for Environmental Information (NCEI) Storm Events Database).

The Severe Storm Risk Score and the Exposure score were added together and a new 0-1 score was calculated to give the final Severe Storm Vulnerability Score (Figure 8).

Figure 8. Severe Storm Hazard Vulnerability Map







Sources: LOJIC, Louisville MSD, US Census Bureau, Louisville EMA, Louisville Water Company, LG&E/KU, National Weather Service, Kentucky Geological Survey, Jefferson County PVA

LOJIC
Louisville/Jefferson County Information Consortium

4.7. Hail Storm

4.7.1.Identify: Hail

Hail is precipitation in the form of spherical or irregular pellets of ice larger than 5 millimeters (0.2 inches) in diameter (American Heritage Dictionary).

Hail is a somewhat frequent occurrence associated with severe thunderstorms. Hailstones grow as ice pellets are lifted by updrafts, and collect super-cooled water droplets. As the pellets grow, hailstones become heavier and begin to fall. Sometimes, hailstones are caught by successively stronger updrafts and are re-circulated through the cloud growing larger each time the cycle is repeated. Eventually, the updrafts can no longer support the weight of the hailstones. As hailstones fall to the ground, they produce a hail-streak (i.e. area where hail falls) that may be more than a mile wide and a few miles long.

Hail Types

Hail is a unique and common hazard capable of producing extensive damage from the impact of these falling objects. Hailstorms occur more frequently during the late spring and early summer months. Most thunderstorms do not produce hail, and ones that do normally produce only small hailstones not more than one-half inch in diameter.

Hail Conversion Chart

Diameter of Hailstones (inches)	Description
0.50	Marble
0.70	Dime
0.75	Penny
0.88	Nickel
1.00	Quarter
1.25	Half Dollar
1.50	Walnut
1.75	Golf Ball
2.00	Hen Egg
2.50	Tennis Ball
2.75	Baseball
3.00	Tea Cup
4.00	Grapefruit
4.50	Softball

4.7.2. Hail Profile

Profile Risk Table	
Period of occurrence:	Year-round
Number of events:	152 (1961-2015)
Probability of events:	2.76
Past Damages	$20,017,000
Warning time:	Minutes to hours
Potential impact:	Large hailstorms can include minimal to severe property and crop damage and destruction.
Potential of injury or death:	Hail storms have a low potential for injury or death.
Possible Extent:	May 1996 – Hail was reported over most of the county resulting in an estimated $20 million in damage to buildings and vehicles.

The effects of large hailstorms can include minimal to severe property and crop damage and destruction. Most thunderstorms do not produce hail, and ones that do normally produce only small hailstones not more than one-half inch in diameter.

Potential Impacts of Hail

Large hailstorms can include minimal to severe property and crop damage and destruction. The combination of gravity and a downward wind known as a downburst (a common occurrence during severe thunderstorms) can propel a hailstone at speeds upwards of 90 mph. At such excessive speeds, large hailstones have been known to penetrate straight through roof coverings and the deck to which they are attached. Although the majority of hailstorms are not quite so severe, even moderate hailstorms can damage buildings, automobiles, crops, and other personal property.

History of Hail Events

The following event detail information is typical of damage and injury caused by hailstorms within the Louisville Metro planning area.

May, 3, 1996
Hail ranging in size from golf ball to baseball was reported throughout the county, with most damage occurring between the airport and the Gene Snyder Freeway in Fern Creek and Jeffersontown areas. Approximately $20million in damages was estimated form this storm to vehicles and buildings.

May 19, 2005
2 events: A lightning strike caused a house fire on Waters Edge Drive. There were also widespread reports of large hail, and a few more reports of non-severe hail in other locations. Flooding of low-lying areas, and streams flowing out of banks, also resulted from the thunderstorms. $10K

April 2, 2006
Quarter size hail broke windows along Bardstown Road. $2K

October 18, 2007

1.25 inch in diameter hail fell in the Crescent Hill area with a storm that later produced a brief EF0 tornado farther east. A cold front with strong upper level support collided with a very moist air mass over the lower Ohio Valley. The result was a widespread outbreak of severe thunderstorms, and six confirmed tornadoes. The storms produced property damage, downed trees and power lines, and large hail. $10K

4.7.3. Assessing Vulnerability Overview

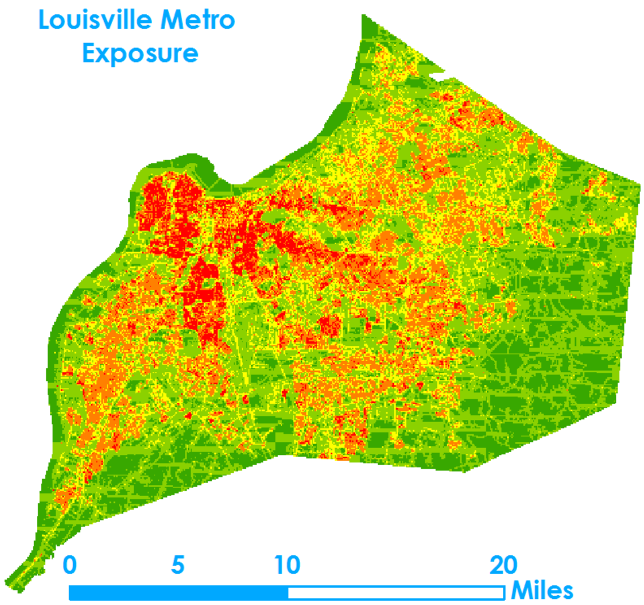
Hail Vulnerability Score = Exposure Score + Risk Score

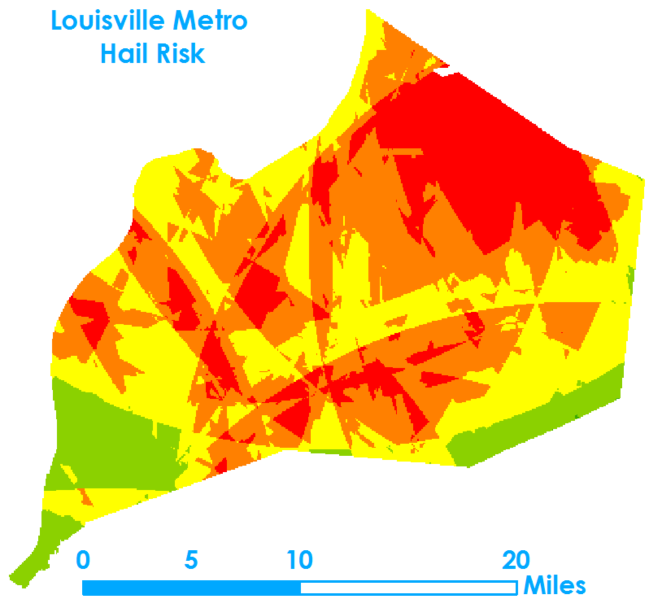
Risk Score = Occurrence Score

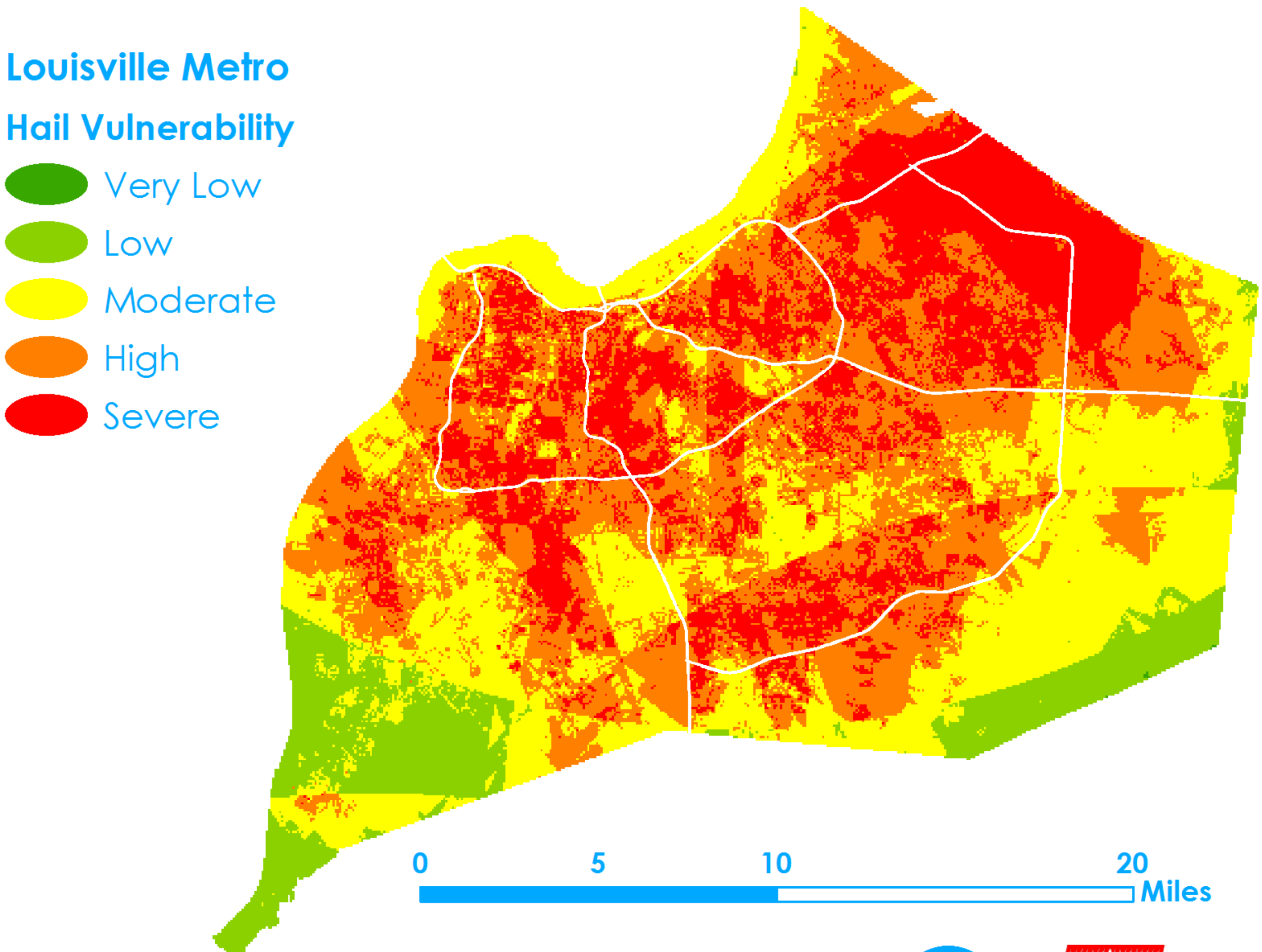
Occurrences = Occurrences were calculated for each grid cell by identifying and counting all Severe Storm events within 25 miles of each cell. Severe Storm events included were all recorded thunderstorm and wind events from 1950 – 2015 (NOAA Storm Prediction Center).

The Hail Risk Score and the Exposure score were added together and a new 0-1 score was calculated to give the final Hail Vulnerability Score (Figure 9).

Figure 9. Hail Hazard Vulnerability Map







Sources: LOJIC, Louisville MSD, US Census Bureau, Louisville EMA, Louisville Water Company, LG&E/KU, National Weather Service, Kentucky Geological Survey, Jefferson County PVA

4.8. Earthquake

4.8.1. Identify: Earthquake

An earthquake is a sudden, rapid shaking of the Earth caused by the breaking and shifting of rock beneath the Earth's surface. For hundreds of millions of years, the forces of plate tectonics have shaped the Earth as the huge plates that form the Earth's surface move slowly over, under, and past each other. Sometimes the movement is gradual while at other times, the plates are locked together, unable to release the accumulating energy. When the accumulated energy grows strong enough, the plates break free releasing the stored energy and producing seismic waves generating an earthquake. The areas of greatest tectonic instability occur at the perimeters of the slowly moving plates, as these locations are subjected to the greatest strains from plates traveling in opposite directions and at different speeds. However, some earthquakes occur in the middle of plates.

Earthquakes result from crustal strain, volcanism, landslides, or the collapse of caverns. An earthquake is the motion or trembling of the ground produced by sudden displacement of rock in the Earth's crust. Ground motion, the movement of the earth's surface during earthquakes or explosions, is the catalyst for most of the damage during an earthquake. Produced by waves generated by a sudden slip of a fault or sudden pressure at the explosive source, ground motion travels through the earth and along its surface. Ground motions are amplified by soft soils overlying hard bedrock, referred to as ground motion amplification. Ground motion amplification can cause an excess amount of damage during an earthquake, even to sites very far from the epicenter.

Earthquakes can affect hundreds of thousands of square kilometers; cause damage to property measured in the tens of billions of dollars; result in loss of life and injury to hundreds of thousands of persons; and disrupt the social and economic functioning of the affected area. Ground shaking from earthquakes can collapse buildings and bridges, disrupt gas, electric, phone service, and sometimes trigger landslides, avalanches, flash floods, fires, and destructive ocean waves (tsunamis). During an earthquake, buildings with foundations resting on unconsolidated landfill and other unstable soil, and trailers and homes not tied to their foundations are at risk because they can be shaken off their mountings. When an earthquake occurs in a populated area, it may cause deaths, injuries, and extensive property damage.

Most property damage and earthquake-related deaths are caused by the failure and collapse of structures due to ground shaking. The level of damage depends upon the amplitude and duration of the shaking, which are directly related to the earthquake size, distance from the fault site and regional geology. Other damaging earthquake effects include landslides, the down-slope movement of soil and rock (mountain regions and along hillsides), and liquefaction, in which ground soil loses the ability to resist shear and flows much like quick sand. In the case of liquefaction, anything relying on the substrata for support can shift, tilt, rupture, or collapse.

The Northridge, California, earthquake of January 17, 1994, struck a modern urban environment generally designed to withstand the forces of earthquakes. Its economic cost, nevertheless, has been estimated at $20 billion. Fortunately, relatively few lives were lost. Exactly one year later, Kobe, Japan, a densely populated community less prepared for earthquakes than Northridge, was devastated by the most costly earthquake ever to occur. Property losses were projected at $96 billion, and at least 5,378 people were killed. These two earthquakes tested building codes and construction practices, as well as emergency preparedness and response procedures.

California experiences the most frequent damaging earthquakes. However, Alaska experiences the greatest number of large earthquakes-most located in uninhabited areas. The largest earthquakes felt in the U. S. were along the New Madrid Fault in Missouri, where a three-month long series of quakes from 1811 to 1812 included three quakes larger than a magnitude of 8 on the Richter Scale. These earthquakes were felt over the entire eastern U. S., with Missouri, Tennessee, Kentucky, Indiana, Illinois, Ohio, Alabama, Arkansas, and Mississippi experiencing the strongest ground shaking.

Earthquake Types

Earthquakes are measured in terms of their magnitude and intensity. Magnitude is measured using the Richter Scale that describes the energy release of an earthquake through a measure of shock wave amplitude. Intensity is most commonly measured using the Modified Mercalli Intensity (MMI) Scale.

The Richter magnitude scale measures an earthquake's magnitude using an open-ended logarithmic scale that describes the energy release of an earthquake through a measure of shock wave amplitude. The earthquake's magnitude is expressed in whole numbers and decimal fractions. Each whole number increase in magnitude represents a 10-fold increase in measured wave amplitude, or a release of 32 times more energy than the preceding whole number value.

The Modified Mercalli Scale measures the effect of an earthquake on the Earth's surface. Composed of 12 increasing levels of intensity that range from unnoticeable shaking to catastrophic destruction, the scale is designated by Roman numerals. The roman numerals, with I corresponding to imperceptible (instrumental) events, IV corresponding to moderate (felt by people awake), to XII for catastrophic (total destruction). The lower values of the scale detail the manner in which people feel the earthquake, while the increasing values are based on observed structural damage. The intensity values are assigned after gathering responses to questionnaires administered to postmasters in affected areas in the aftermath of the earthquake.

4.8.2. Earthquake Profile

Profile Risk Table	
Period of occurrence:	Year-round
Number of events:	0 epicenter occurrences in Louisville Metro. However regional events have affected the area as recently as 2008.
Probability of events:	0 epicenter probability of earthquake with M>5.0 within 500 years & 50 km 0.04.
Past Damages	$0
Warning time:	None
Potential impact:	Impacts human life, health, and public safety. Utility damage and outages, infrastructure damage (transportation and communication systems), structural damage, fire, damaged or destroyed critical facilities, and hazardous material releases. Can cause severe transportation problems and make travel extremely dangerous. Aftershocks and secondary events could trigger landslides, releases of hazardous materials, and/or dam and levee failure and flooding.
Potential of injury or death:	Earthquakes in Louisville have a low potential for injury or death.
Possible Extent:	Unknown

Specific fault systems in Kentucky include the Rough Creek and Pennyrile Fault Systems, running east-west to the southwest of the Louisville Metro area, and the Cincinnati Arch that runs roughly north-south through Lexington some 75 miles to the east. See map below of Kentucky's fault lines.

In general, these faults have been inactive for thousands of years. Earthquakes may occur in areas where faults have not yet been identified; this situation presented itself when an earthquake occurred in Sharpsburg in 1980 in an area previously not known to include a fault.

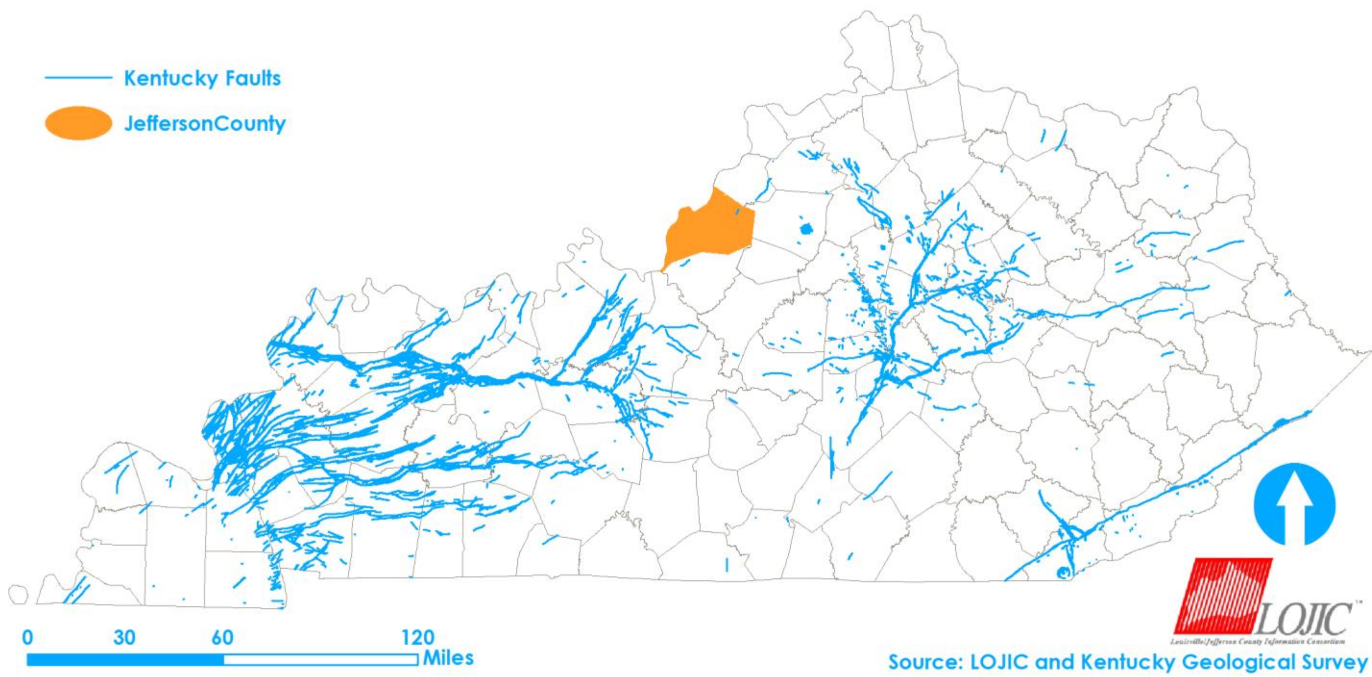
Fault lines run through much of Kentucky, with each of the fifteen area development districts (ADDs) containing at least one fault line or fault system. A number of these systems have remained geologically inactive for significant amounts of time, but others - scientists believe are overdue for a surge in activity.

The three (3) seismic zones most likely to put Kentucky at risk are centered outside of the state, but pose a very real threat to the Commonwealth's citizens.

- The Eastern Tennessee Seismic Zone extends from southwest Virginia to northeast Alabama and is one of the most seismically active fault systems in the Southeast. Although the zone has not experienced a large earthquake in historic times, a few minor earthquakes have caused slight damage. The largest recorded earthquake in this seismic zone was a magnitude 4.6 which occurred in 1973 near Knoxville. Sensitive seismographs have recorded hundreds of earthquakes too small to be felt in this seismic zone. Small, non-damaging, felt earthquakes occur about once a year. No evidence for larger prehistoric shocks has been discovered, yet the micro-earthquake data suggest coherent stress accumulation within a large volume. Physical processes for reactivation of basement faults in this region could involve a weak lower crust and increased fluid pressures within the upper to middle crust.

- The New Madrid Seismic Zone (NMSZ), located in the central Mississippi Valley, is generally demarked on the north by the confluence of the Ohio and Mississippi Rivers. From this point in southern Illinois, the zone runs southwest, through western Kentucky (near Fulton), through eastern Missouri and western Tennessee and terminates in northeastern Arkansas, crossing the Mississippi River three times.

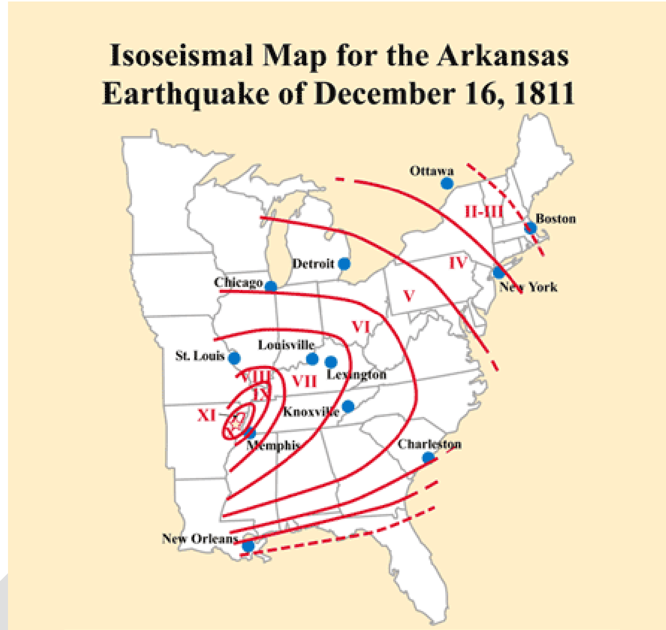
- The Wabash Valley Seismic Zone which threatens southern Illinois, Indiana, and Kentucky, shows evidence of large earthquakes in its geologic history. Since 1895, The Wabash Valley Fault Zone has experienced more moderate quakes than the New Madrid Seismic Zone. Some prehistoric quakes which occurred in this zone between 4,000 and 10,000 years ago may have been larger than M6.0. Earthquake ground shaking is amplified by lowland soils, and modern earthquakes of M5.5 to 6.0 in the Wabash Valley Fault Zone could cause substantial damage if they occur close to the populated river towns and cities along the Wabash River and tributaries.



Kentucky Earthquake History

Although there has not been a major earthquake for nearly two hundred years, losses caused by earthquakes in Kentucky have been estimated at about $18.7 million on an annualized basis by FEMA (2001).

Kentucky is affected by earthquakes from several seismic zones in and around the state. The most important one is the New Madrid Seismic Zone, in which at least three great earthquakes, each estimated to have been greater than magnitude 8 on the Richter scale, occurred from December 1811 to February 1812. Though the state was sparsely settled, these great earthquakes affected the whole Commonwealth of Kentucky.



Modified Mercalli Intensity Scale

INTENSITY		EFFECTS	AVE. PEAK ACCELERATION
VI	Strong	Felt by all. Damage slight.	0.06–0.07g
VII	Very Strong	Everybody runs outdoors. Considerable damage to poorly designed buildings.	0.10–0.15g
VIII	Destructive	Considerable damage to ordinary buildings.	0.25–0.30g
IX	Ruinous	Great damage to ordinary buildings	0.50–0.55g
X	Disastrous	Many buildings destroyed.	>0.60g
XI	Disastrous	Few, if any, structures remain standing	

(Simplified from Bolt, 1993)

Source: Kentucky Geological Survey

Most of the activity in Kentucky has occurred in the western portion of the State, near the New Madrid seismic zone. The series of catastrophic earthquakes at New Madrid, Missouri, in 1811 - 1812, dominates the seismic history of the middle Mississippi Valley.

Reports of chimneys being knocked down in many places in Kentucky resulted from the 1811 - 1812 earthquakes at New Madrid, Missouri. A detailed record of 1,874 tremors from the initial shock of December 16, 1811, through March 15, 1812, was kept by Mr. Jared Brooks at Louisville, Kentucky. Shocks continued to occur at frequent intervals for at least two years, thus the total number of shocks was much greater. It is not unlikely that between 2,000 and 3,000 tremors were felt in Kentucky in 1811 and 1812. Reelfoot Lake, a small portion of which extends into Kentucky, is a present-day reminder of the great forces associated with these earthquakes.

Damage associated with the major earthquakes in 1811 and 1812 was not significant due to the low level of development in the area at the time. However, today over 12.5 million people live in the region impacted by the 1811 to 1812 events. The map shows the Modified Mercalli intensity for the first event of the 1811-1812 New Madrid earthquakes.

The University of Memphis estimates that, for a 50-year period, the probability of a repeat of the New Madrid 1811-1812 earthquakes with:

- A magnitude of 7.5 - 8.0 is 7 to 10%.
- A magnitude of 6.0 or larger is 25 to 40%.

Other historical earthquakes in Kentucky include:

March 12, 1878
A shock was reported at Columbus, Kentucky. A section of the bluff along the Mississippi River caved in rated as intensity V on the Modified Mercalli Scale.

October 26, 1915
An earthquake at Mayfield was reported to have shaken pictures from walls and rated as intensity V on the Modified Mercalli Scale.

December 7, 1915
A sharp earthquake with an epicenter near the mouth of the Ohio River occurred. Buildings were strongly shaken, windows and dishes rattled, and loose objects were shaken in western Kentucky and adjoining regions (intensity V-VI). The total felt area covered 60,000 square miles.

December 18, 1916
Hickman experienced a strong shock. Reports indicated bricks were shaken from chimneys at Hickman and New Madrid, Missouri (intensity VI-VII).

March 2, 1924
An earthquake near the point of the December 1915 event occurred. No damage was reported and the felt area was much less, about 15,000 square miles.

September 2, 1925
A broad area of Kentucky, Illinois, Indiana, and Tennessee, estimated at about 75,000 square miles, was affected by an earthquake. It was apparently centered near Henderson, where some landslides were noted. At Louisville, about 100 miles distant, a chimney fell and a house reportedly sank.

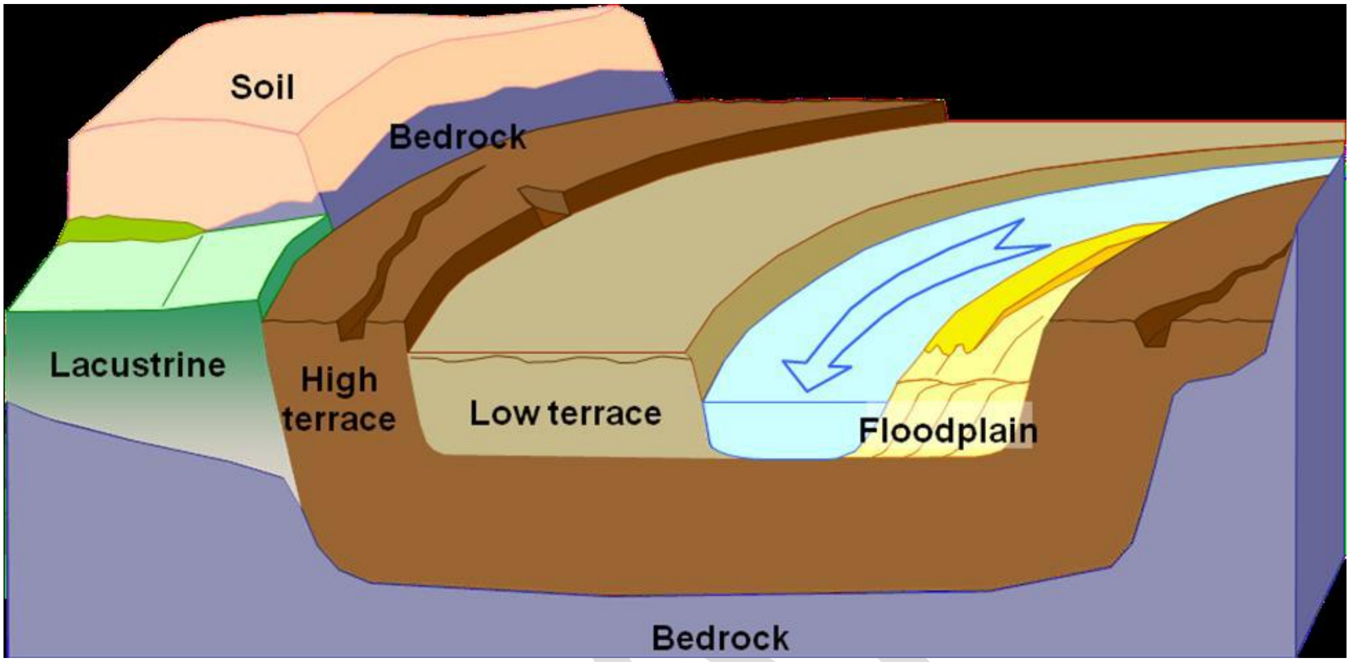
July 27, 1980
In Sharpsburg KY, M5.2, MMI VII, Louisville VI. An earthquake measuring 5.2 on the Richter scale occurred near Sharpsburg in Bath County and caused an estimated $3 million in damage; 269 homes and 37 businesses in nearby Maysville were damaged.

April 18, 2008
M5.4, in Louisville II-V.

Louisville Metro Potential Earthquake Damage
Seismic events generate energy waves that attenuate as they move away from the epicenter of the event. The nature of the crustal rock of the Central U.S. results in a low degree of wave attenuation. Therefore, seismic shocks that occur in the central portion of the U.S. will affect a far greater area than similar events on the western coast.

The greatest hazard potential for earthquakes exists in highly populated areas, because these areas tend to have a greater number of tall buildings that are more vulnerable to seismic impact. Buildings and infrastructure (roads, bridges, etc.) built during the 1920s to 1960s are also generally more susceptible to seismic movement than newer construction.

Areas of softer soil and potential liquefaction generally result in increased vulnerability to the impacts of an earthquake. In Louisville Metro, old portions of the city and heavy industry are located on the alluvial deposits adjacent to the Ohio River. New portions of the city, including malls and the surrounding suburbs are constructed on the clay materials derived from limestone bedrock (ULY CIR 2004).



By W. Andrews, KGS

4.8.3. Assessing Vulnerability: Earthquake

Earthquake Vulnerability Score = Exposure Score + Risk Score

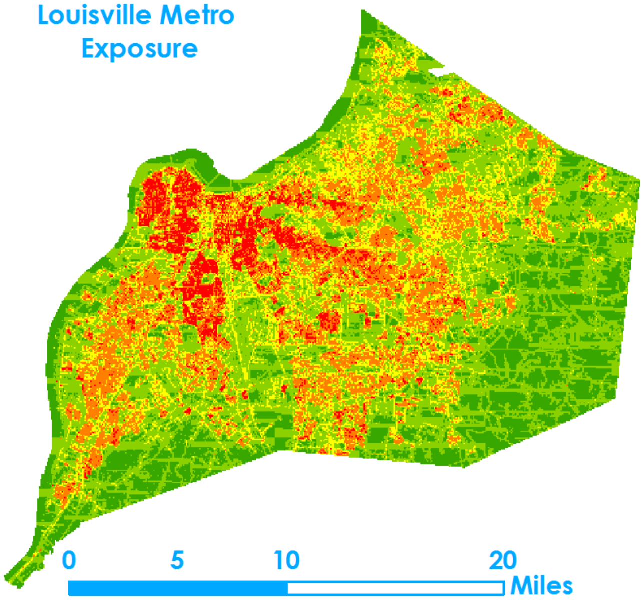
Risk Score = Geographic Extent

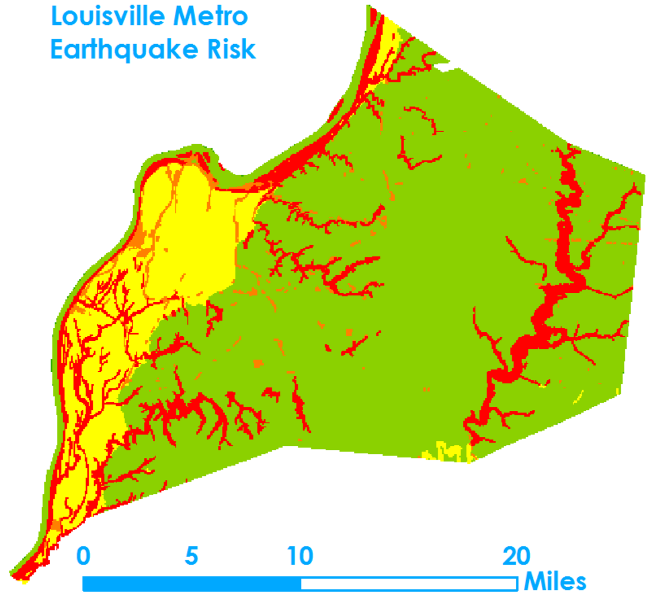
Geographic Extent = earthquake risk of each grid cell based on KGS earthquake data

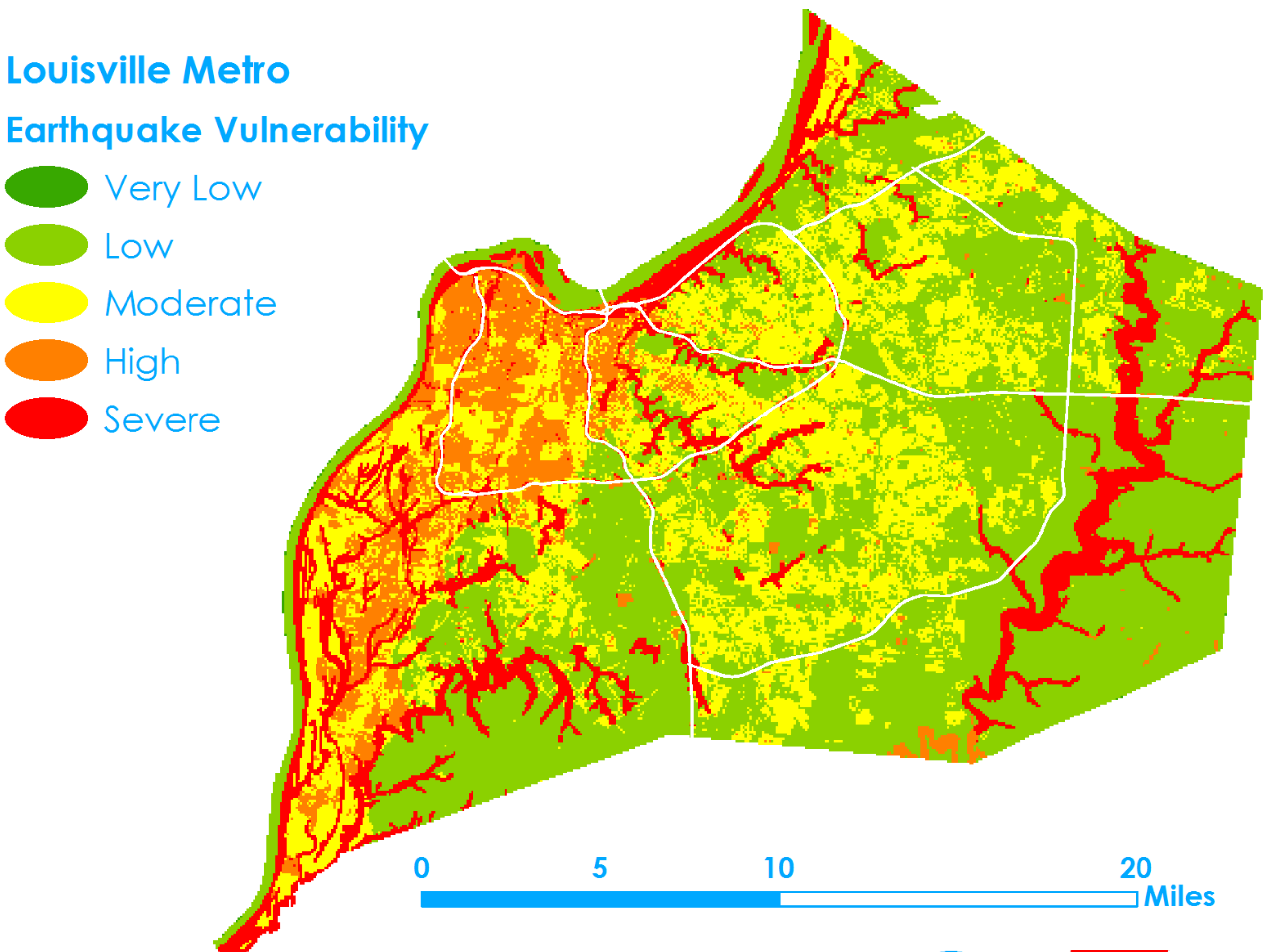
Amplification and liquefaction values determined by Dr. Zhenming Wang (KGS) as an update to USGS values. Dr. Wang's scale was 0-3 for amplification and 0-2 for liquefaction. Dr. Wang's earthquake risk levels were assigned to each grid cell for liquefaction and amplification. The risk levels were scored 0-1 for both types. Amplification score was added to the liquefaction score and a 0-1 score was calculated on total, resulting in the Geographic Extent score.

The Earthquake Risk Score and the Exposure score were added together and a new 0-1 score was calculated to give the final Earthquake Vulnerability Score (Figure 10).

Figure 10. Earthquake Hazard Vulnerability Map







Sources: LOJIC, Louisville MSD, US Census Bureau, Louisville EMA, Louisville Water Company, LG&E/KU, National Weather Service, Kentucky Geological Survey, Jefferson County PVA

LOJIC
Louisville/Jefferson County Information Consortium

4.9. Karst/Sinkhole

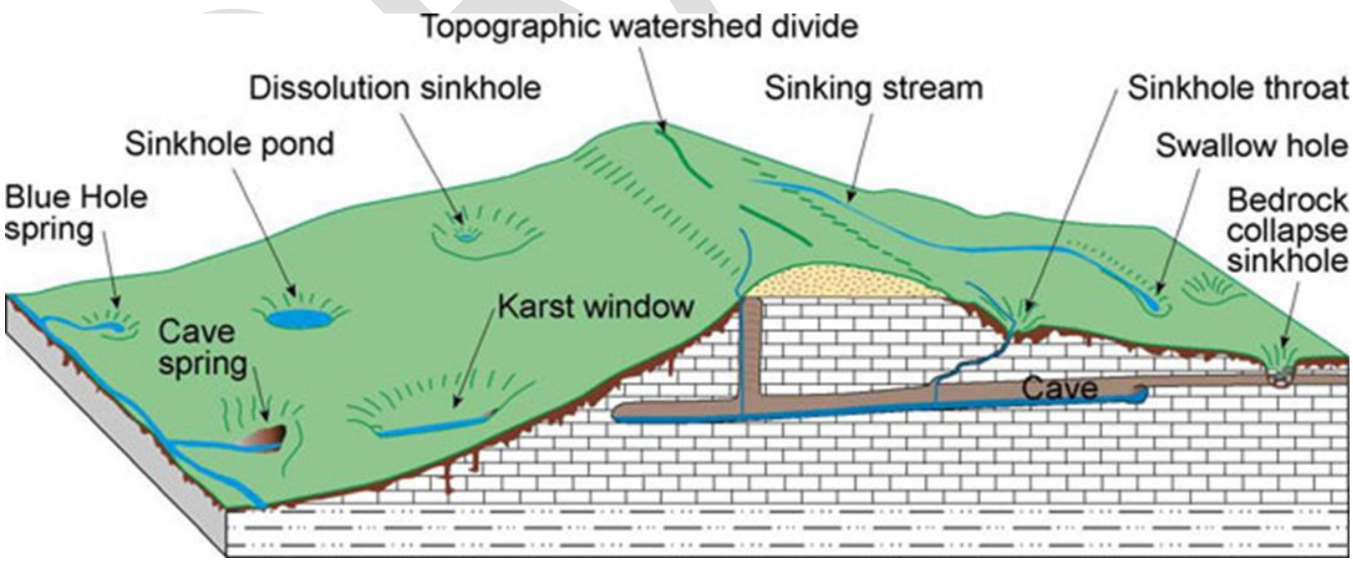
4.9.1. Identify: Karst/Sinkhole

Karst is an area of irregular limestone in which erosion has produced fissures, sinkholes, underground streams, and caverns. A sinkhole is a natural depression in a land surface communicating with a subterranean passage, generally occurring in limestone regions and formed by solution or by collapse of a cavern roof (American Heritage Dictionary).

Karst refers to a type of topography formed in limestone, dolomite, or gypsum by dissolution of these rocks by rain and underground water. It is characterized by closed depressions or sinkholes and underground drainage. During the formation of Karst terrain, water percolating underground enlarges subsurface flow paths by dissolving the rock. As some subsurface flow paths are enlarged over time, water movement in the aquifer changes character from one where ground water flow was initially through small, scattered openings in the rock, to one where most flow is concentrated in a few, well-developed conduits. As the flow paths continue to enlarge, caves may be formed and the ground water table may drop below the level of surface streams. Surface streams may then begin to lose water to the subsurface. As more of the surface water is diverted underground, surface streams and stream valleys become a less conspicuous feature of the land surface and are replaced by closed basins. Funnels or circular depressions called sinkholes often develop at some places in the low points of these closed basins.

Karst Landscape

A karst landscape has sinkholes, sinking streams, caves, and springs. The term "karst" is derived from a Slavic word that means barren, stony ground. It is also the name of a region in Slovenia near the border with Italy that is well known for its sinkholes and springs. Geologists have adopted karst as the term for all such terrain. The term "karst" describes the whole landscape, not a single sinkhole or spring.



Source: Kentucky Geological Survey

A karst landscape most commonly develops on limestone, but can develop on several other types of rocks, such as dolostone (magnesium carbonate or the mineral dolomite), gypsum, and salt. Precipitation infiltrates into the soil and flows into the subsurface from higher elevations and generally toward a stream at a lower elevation. Weak acids found naturally in rain and soil water slowly dissolve the tiny fractures in the soluble bedrock, enlarging the joints and bedding planes.

Fifty-five percent of Kentucky sits atop carbonate rocks that are prone to developing karst. Karst hazards include sinkhole flooding, sudden cover collapse, and leakage around dams. The estimated damage caused by karst hazards every year in Kentucky is between $0.5 million and $1 million.

Karst as Geologic Hazard

A geologic hazard is a naturally occurring geologic condition that may result in property damage or is a threat to the safety of people. Many hazards to man-made structures can be associated with the type of bedrock, the presence of faults, and other earth processes that occur in Kentucky. Earthquakes get the most press coverage and are the most notorious. Annually, landslides, shrink-swell soils, and flooding cause more damage than earthquakes in Kentucky because they happen more often. Karst hazards cause less damage than earthquakes or landslides, perhaps $500,000 to $2,000,000 of economic loss annually, but can still have devastating effect on properties, infrastructures and people.

Four geologic hazards are associated with karst.

- Two common karst-related geologic hazards -- cover-collapse sinkholes and sinkhole flooding -- cause the most damage to buildings.
- A third karst hazard is relatively high concentrations of radon, sometimes found in basements and crawl spaces of houses built on karst.
- Finally, the hydrogeology of karst aquifers makes the groundwater vulnerable to pollution, and this vulnerability may also be considered a type of geologic hazard.

Land subsidence occurs when large amounts of ground water have been withdrawn from certain types of rocks, such as fine-grained sediments. The rock compacts because the water is partly responsible for holding the ground up. When the water is withdrawn, the rock falls in on itself. Land subsidence can occur unnoticed because it covers large areas rather than in a small spot, like a sinkhole. Subsidence not only damages structures built immediately above the subsiding area, but also sets up lateral stresses that may severely damage adjacent structures.

Sinkhole Types

- Cover-Collapse Sinkholes occur in the soil or other loose material overlying soluble bedrock. Sinkholes that suddenly appear form in two ways. I
    - In the first way, the bedrock roof of a cave becomes too thin to support the weight of the bedrock and the soil material above it. The cave roof then collapses, forming a bedrock-collapse sinkhole. Bedrock collapse is rare and the least likely way a sinkhole can form, although it is commonly incorrectly assumed to be the way all sinkholes form.
    - The second way sinkholes can form is much more common and much less dramatic. The sinkhole begins to form when a fracture in the limestone bedrock is enlarged by water dissolving the limestone. As the bedrock is dissolved and carried away underground, the soil gently slumps or erodes into the developing sinkhole. Once the underlying conduits become large enough, insoluble soil and rock particles are carried away too.

  Cover-collapse sinkholes can vary in size from 1 or 2 feet deep and wide, to tens of feet deep and wide. The thickness and cohesiveness of the soil cover determine the size of a cover-collapse sinkhole.

- Solution sinkholes result from increased groundwater flow into higher porosity zones within the rock, typically through fractures or joints within the rock. An increase of slightly acidic surface water into the subsurface continues the slow dissolution of the rock matrix, resulting in slow subsidence as surface materials fill the voids.
- Raveling sinkholes form when a thick overburden of sediment over a deep cavern caves into the void and pipes upward toward the surface. As the overlying material or "plug" erodes into the cavern, the void migrates upward until the cover can no longer be supported and then subsidence begins.

Sinkhole Flooding

Sinkhole flooding is a naturally occurring event that usually follows the same storms that cause riverine flooding, so it is often not recognized as Karst-related. Flood events will differ not only because of the amount of precipitation, but also because the drainage capacity of individual sinkholes can change, sometimes very suddenly, as the Karst landscape evolves. Sinkholes can also flood when their outlets are clogged, preventing water from being carried away as fast as it flows in. Trash thrown into a sinkhole can clog its throat, as can soil eroded from fields and construction sites, or a natural rock fall near the sinkhole's opening. Sometimes the conduit itself is too narrow because it has recently (in the geologic sense) captured a larger drainage basin. The reach of a conduit downstream from constriction could carry a higher flow than it is receiving were it not for this restriction.

Sinkholes flood more easily around development (roofs, parking lots, highways), which increases both the total runoff and the rapidity of runoff from a storm. Another reason that sinkholes flood is back-flooding, the outcome when the discharge capacity of the entire Karst conduit network is exceeded. Some up-gradient sinkholes that drain normally during the short, modest accumulation of storms may actually become springs that discharge water during prolonged rainfall.

Land Surface Indicators of Sinkhole Collapse

- Circular and linear cracks in soil, asphalt, and concrete paving and floors
- Depressions in soil or pavement that commonly result in ponds of water
- Slumping, sagging, or tilting of trees, roads, rails, fences, pipes, poles, sign boards, and other vertical or horizontal structures
- Downward movement of small-diameter vertical or horizontal structures
- Fractures in foundations and walls, often accompanied by jammed doors and windows
- Small conical holes that appear in the ground over a relatively short period of time
- Sudden muddying of water in a well that has been producing clear water
- Sudden draining of a pond or creek

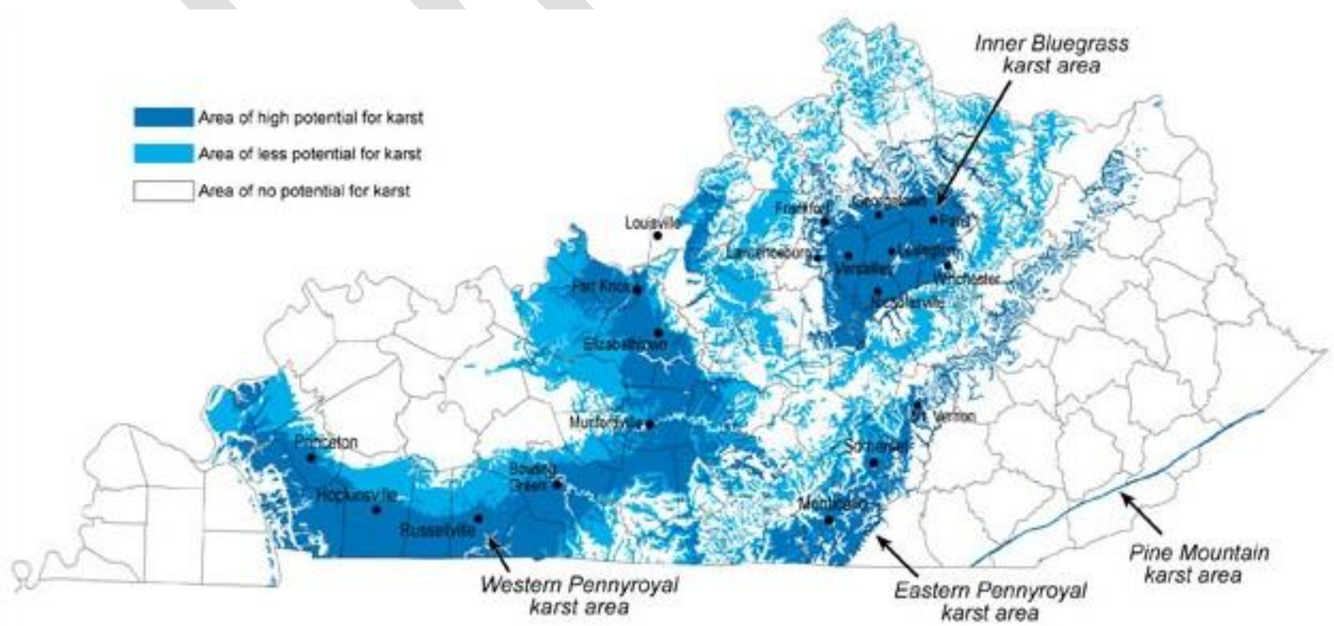
4.9.2. Profile: Karst/Sinkhole

Profile Risk Table	
Period of occurrence:	At any time
Number of events:	Unknown. 443 mapped sinkholes
Probability of events:	N/A
Past Damages	$0
Warning time:	Weeks to months, according to monitoring or maintenance.
Potential impact:	Economic losses such as decreased land values and Agro-business losses. May cause minimal to severe property damage and destruction. May cause geological movement, causing infrastructure damages.
Potential of injury or death:	Karst and sinkholes in Louisville have a low potential for injury or death.
Possible Extent:	A small section of a roadway or part of a structure.

Karst landscapes and aquifers form when water dissolves limestone, gypsum, and other rocks. The surface expression of Karst includes sinkholes, sinking streams and springs. Karst hazards include: sinkhole flooding, sudden cover collapse, leakage around dams, and collapse of lagoons resulting in waste spills and radon infiltration into homes. Sinkholes are among the most common problems of living in a karst area.

Kentucky is one of the most famous karst areas in the world. Much of the state's beautiful scenery, particularly the horse farms of the Inner Bluegrass, is the result of development of karst landscape. The karst topography of Kentucky is mostly on limestone, but also some dolostone. The areas where those rocks are near the surface closely approximate where karst topography will form.

The image below shows the outcrop of limestone and dolostone and closely represents the karst areas. The bedrock is millions of years old, and the karst terrain formed on them is hundreds of thousands of years old. In humid climates such as Kentucky's, it may be assumed that all limestone has karst development, although that development may not be visible at the surface.



Source: Kentucky Geological Survey

The outcrop area of the limestone bedrock in Kentucky has been used to estimate the percentage of karst terrain or topography in the state. About 55 percent of Kentucky is underlain by rocks that could develop karst terrain, given enough time. About 38 percent of the state has at least some karst development recognizable on topographic maps, and 25 percent of the state is known to have well-developed karst features. Some Kentucky cities located on karst include (in the Inner Bluegrass) Frankfort, Louisville, Lexington, Lawrenceburg, Georgetown, Winchester, Paris, Versailles, and Nicholasville; (in the Western Pennyroyal) the communities of Fort Knox, Bowling Green, Elizabethtown, Munfordville, Russellville, Hopkinsville, and Princeton; (in the Eastern Pennyroyal) Somerset, Monticello, and Mount Vernon.

Historical Impact

Kentucky contains one of the world's largest Karst-ridden topographies. Springs and wells in Karst areas supply water to tens of thousands of homes. Much of Kentucky's prime farmland is underlain by Karst, as is a substantial amount of the Daniel Boone National Forest with its important recreational and timber resources.

Caves are also important Karst features, providing recreation and unique ecosystems. Mammoth Cave is the longest surveyed cave in the world, with more than 350 miles of passages. Two other caves in the state stretch more than 30 miles, and nine Kentucky caves are among the 50 longest caves in the U.S.

The most noticeable hazards in Kentucky are sinkhole flooding and cover collapse. Soil collapses are common in karst terrain, where water drains to caves through fissures in the bedrock. Over time, domes of soil form over these fissures and new development increases the drainage into these fissures, forming a sinkhole. Unfortunately, collapses are seldom reported to any central agency.

Karst Potential Impact in Louisville

Damage to infrastructure from sinkhole flooding and cover collapse is so common in Kentucky that it is typically dealt with by local authorities as a routine matter. Throughout the state, many reservoirs of all sizes have leaking dams or leakage through carbonate bedrock around the dam. Louisville Metro is vulnerable to karst and sinkhole flooding. Following is a map of the sinkholes and karst areas in Louisville Metro.

Strategies to Avoid Sinkhole Collapse

- Karst areas should be mapped thoroughly to help identify buried sinkholes and fracture trends. Geophysical methods, aerial photography, and digitally enhanced multi-spectral scanning can identify hidden soil drainage patterns, stressed vegetation, and moisture anomalies in soils over sinkholes.
- In large sinkholes, use bridges, pilings, pads of rock, concrete, special textiles, paved ditches, curbs, grouting, flumes, overflow channels, or a combination of methods to provide support for roads and other structures.
- Large buildings should not be built above domes in caves.

4.9.3. Assessing Vulnerability: Karst/Sinkhole

Karst/Sinkhole Vulnerability Score = Exposure Score + Risk Score

Risk Score = Geographic Extent + Occurrence Score

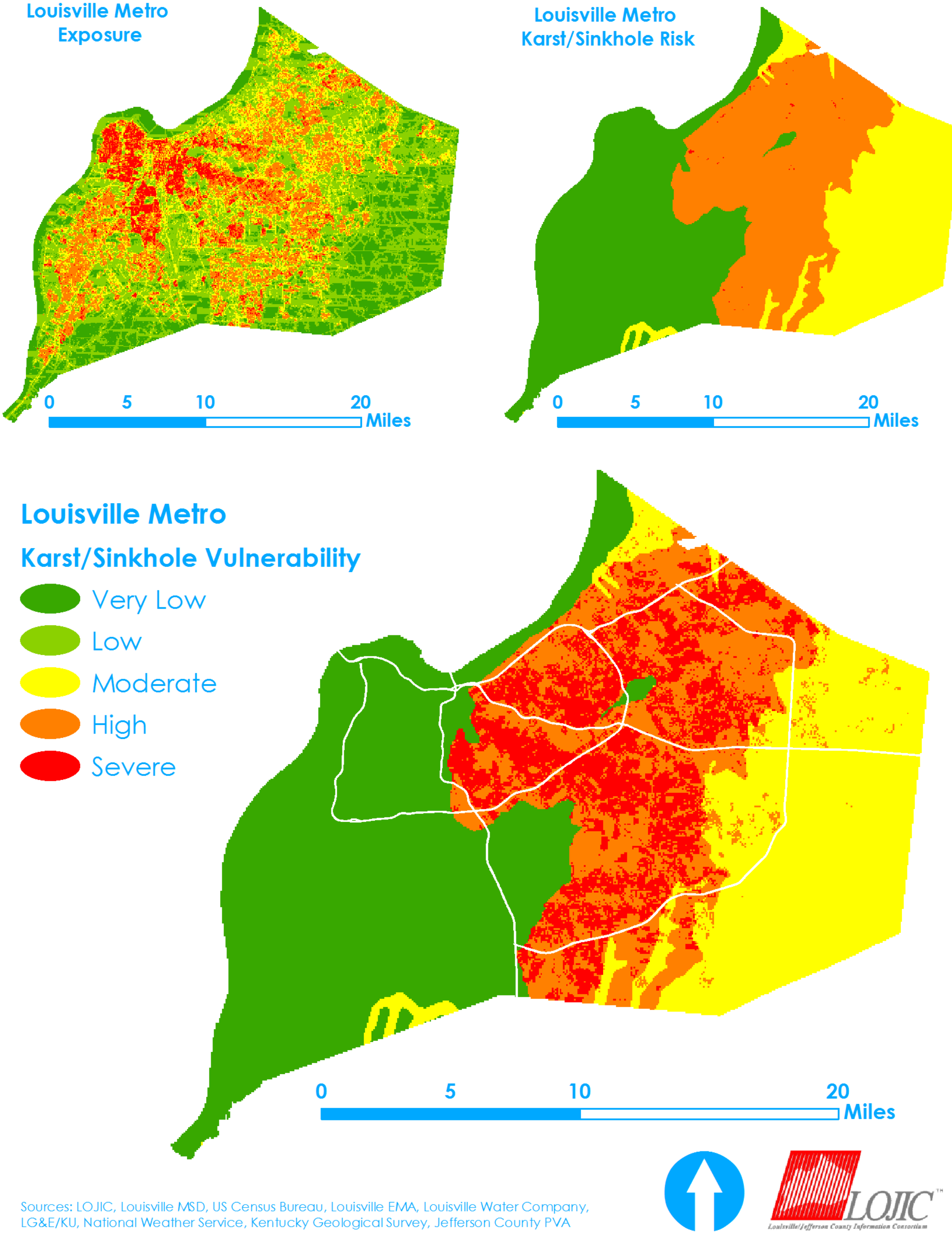
Geographic Extent = Karst risk of each grid cell based on KGS karst data. Karst areas are mapped for Louisville Metro with karst risk levels ranging from none to moderate. Karst risk values were assigned to each grid cell and then 0-1 score was calculated.

Occurrence Score = number of sinkholes in each grid cell. The sinkholes were totaled in each grid cell and then a 0-1 score was calculated for each cell

The occurrence score was added to geographic extent score and total was then scored 0-1.

The Karst/Sinkhole Risk Score and the Exposure score were added together and a new 0-1 score was calculated to give the final Karst/Sinkhole Vulnerability Score (Figure 11).

Figure 11. Karst/Sinkhole Hazard Vulnerability Map



Sources: LOJIC, Louisville MSD, US Census Bureau, Louisville EMA, Louisville Water Company, LG&E/KU, National Weather Service, Kentucky Geological Survey, Jefferson County PVA

4.10. Landslide

4.10.1. Identify: Landside

Landslides occur when masses of rock, earth, or debris move down a slope. Landslides may be very small or very large, and can move at slow to very high speeds. Many landslides have been occurring over the same terrain since prehistoric times. They are activated by storms and fires and by human modification of the land. New landslides occur because of rainstorms, earthquakes, volcanic eruptions, and various human activities.

Mudflows or debris flows differ from landslides because they are rivers of rock, earth, and other debris saturated with water. Mudflows develop when water rapidly accumulates in the ground, such as during heavy rainfall or rapid snowmelt, changing the earth into a flowing river of mud or "slurry". A slurry can flow rapidly down slopes or through channels, and can strike with little or no warning at avalanche speeds. A slurry can travel several miles from its source, growing in size as it picks up trees, cars, and other materials along the way. Landslides pose serious threats to highways and structures that support fisheries, tourism, timber harvesting, mining, and energy production, as well as general transportation.

Most losses from landslides and soil creep occur in cities developed on gently sloping hillsides. Although a landslide may occur almost anywhere, from man-made slopes to natural, pristine ground, most slides occur in areas that have experienced sliding in the past. All landslides are triggered by similar causes. These can be weaknesses in the rock and soil, earthquake or volcanic activity, the occurrence of heavy rainfall or snowmelt, or construction activity changing some critical aspect of the geological environment. Landslides that occur following periods of heavy rain or rapid snowmelt worsen the accompanying effects of flooding.
Areas that are generally prone to landslide hazards include existing old landslides; the bases of steep slopes; the bases of drainage channels; and developed hillsides where leach-field septic systems are used.

Areas that are typically considered safe from landslides include areas that have not moved in the past; relatively flat-lying areas away from sudden changes in slope; and areas at the top or along ridges, set back from the tops of slopes.

Landslide Types

- Slides of soil or rock involve downward displacement along one or more failure surfaces. The material from the slide may be broken into a number of pieces or remain a single, intact mass. Sliding can be rotational, where movement involves turning about a specific point. Sliding can be translational, where movement is down slope on a path roughly parallel to the failure surface. The most common example of a rotational slide is a slump, which has a strong, backward rotational component and a curved, upwardly-concave failure surface.
- Flows are characterized by shear strains distributed throughout the mass of material. They are distinguished from slides by high water content and distribution of velocities resembling that of viscous fluids. Debris flows are common occurrences in much of North America. These flows are a form of rapid movement in which loose soils, rocks, and organic matter, combined with air and water, form a slurry that flows downslope. The term "debris avalanche" describes a variety of very rapid to extremely rapid debris flows associated with volcanic hazards. Mudflows are flows of fine-grained materials, such as sand, silt, or clay, with high water content. A subcategory of debris flows, mudflows contains less than

50 percent gravel. Lateral spreads are characterized by large elements of distributed, lateral displacement of materials. They occur in rock, but the process is not well-documented and the movement rates are very slow.

- Lateral spreads can occur in fine-grained, sensitive soils such as quick clays, particularly if remolded or disturbed by construction and grading. Loose, granular soils commonly produce lateral spread through liquefaction. Liquefaction can occur spontaneously, presumably because of changes in pore-water pressures, or in response to vibrations such as those produced by strong earthquakes.
- Falls and Topples. Falls occur when masses of rock or other material detach from a steep slope or cliff and descend by free fall, rolling, or bouncing. These movements are rapid to extremely rapid and are commonly triggered by earthquakes. Topples consist of forward rotation of rocks or other materials about a pivot point on a hill slope. Toppling may culminate in abrupt falling, sliding, or bouncing, but the movement is tilting without resulting in collapse. Data on rates of movement and control measures for topples is sparse.

Slope failures are major natural hazards in many areas throughout the world. Slope failures are also referred to as mass movements. A slope failure is classified based on how it moves and the type of material being moved.

Five major types of slope failures have been identified:

- Creep: very slow movement of rock or soil downslope.
- Falls: very rapid fall of rock and earth material from vertical or near vertical slopes.
- Flows: slow to rapid movement of rock, soil, snow, or ice. Types of flows include mudflows, earthflows, debris flows, and snow avalanches.
- Slides: Very slow to very rapid movement of soil or rock. This category includes rockslides, earth slides, and slumps.
- Subsidence: slow to very rapid collapse of rock or soil into underlying spaces. Sinkholes in Karst/Sinkhole landscapes are a common example.

4.10.2. Landslide Profile

Profile Risk Table	
Period of occurrence:	At any time. Chance of occurrence increases after heavy rainfall, snowmelt, or construction activity.
Number of events:	5 (1993-2015)
Probability of events:	.22
Past Damages	$0
Warning time:	Weeks to months, depends on inspection for weaknesses in rock and soil. Some landslides move slowly and cause damage gradually, whereas others move so rapidly that they can destroy property and take lives suddenly and unexpectedly.
Potential impact:	Economic losses such as decreased land values, Agro-business losses, disruption of utility and transportation systems, and costs for any litigation. May cause geological movement, causing infrastructure damages ranging from minimal to severe.
Potential of injury or death:	Landslides have a low potential for injury or death in Louisville
Possible Extent:	A section of roadway or a single structure

Gravity is the force driving landslide movement. Factors that allow the force of gravity to overcome the resistance of earth material to landslide movement include: saturation by water, steepening of slopes by erosion or construction, alternate freezing or thawing, and earthquake shaking. Population increase, rapid urbanization, and development will cause an increasing trend in landslide activity.

Kentucky Landslide History

For Kentucky, KGS reports a large landslide in Hickman, in western Kentucky, destroyed many houses, and more than $10 million has been spent to try to fix it. About $1 million has been spent to repair damage caused by landslides on the Audubon Parkway between Owensboro and Henderson.

In many locations, both geologic and atmospheric processes may play a role in the movement of a slope. Slope failures can occur in any season, but are more likely to be triggered by weather events such as rain, snow, or freezing and thawing of soil water. With the exception of slope failures triggered by geologic processes, most slope failures occur between spring and fall.

- In early spring, snowmelt can increase pore pressures in the soil, increasing the risk of slope failures.
- During summer and fall, intense or prolonged rainfall can trigger slope failures.
- Freeze-thaw events, which usually happen during spring and fall but also during warm winters, can increase the potential for slope failure.

Potential Costs

Public and private economic losses from landslides include not only the direct costs of replacing and repairing damaged facilities, but also the indirect cost associated with lost productivity, disruption of utility and transportation systems and costs for any litigation. Other indirect costs may include loss of tax revenue on property devalued because of landslides, loss of real estate value in landslide-prone areas, and environmental effects such as water quality. Some indirect costs are difficult to evaluate, thus estimates are usually conservative or simply ignored. If indirect costs were realistically determined, they likely would exceed direct costs.

Much of the economic loss is borne by Federal, State, and local agencies responsible for disaster assistance, and highway maintenance and repair. Flood insurance does not cover landslides. Private costs involve mainly damage to land and structures. A severe landslide can result in financial ruin for the property owners because landslide insurance (except for debris flow coverage) or other means of spreading the costs of damage are unavailable.

Landslide Potential Impact in Louisville Metro

Landslides are more likely to occur in the southwest portion of Louisville Metro. Probability increases at the base of a steep slope; the base of a drainage channel; and developed hillsides where leach-field septic systems are used. Several studies have shown that almost any modification of a slope by people increases the risk of slope movement, especially in areas already susceptible.

Landslide problems are usually related to certain rock formations that yield soils that are unstable on moderate to steep slopes. Often, slopes are cut into or oversteeped to create additional level land for development. Individuals can take steps to reduce their personal risk.
Steep slopes are more susceptible to landslides and should be avoided when choosing a building site.

- Slope stability decreases as water moves into the soil. Springs, seeps, roof runoff, gutter down spouts, septic systems, and site grading that cause ponding or runoff are sources of water that often contribute to landslides.
- Changing the natural slope by creating a level area where none previously existed adds weight and increases the chance of a landslide.
- Poor site selection for roads and driveways.
- Improper placement of fill material.
- Removal of trees and other vegetation. Plants, especially trees, help remove water and stabilize the soil with their extensive root systems.

Louisville Metro Landslide Potential

Unstable soils also contribute to landslide potential in Louisville Metro as shown on "Core Graphic 4" of the Louisville and Jefferson County Comprehensive Plan: Soil types that are subject to mass wasting such as creep, slump or even landslides and mudslides coincide with slopes over 6 percent and the presence of underlying shale bedrock. Listed below are the soil types that are considered unstable due to the presence of underlying shale. Any highly sloped area may be subject to unstable conditions regardless of the presence of underlying shale.

Louisville Metro Soil Types

HgD	Holston gravelly silt loam	12 to 20 percent slopes
HgE	Holston gravelly silt loam	20 to 30 percent slopes
MpD2	Memphis silt loam	12 to 20 percent slopes, eroded
MpE2	Memphis silt loam	20 to 30 percent slopes, eroded
RcE	Rockcastle silt loam	15 to 30 percent slopes
ZaC2	Zanesville silt loam	6 to 12 percent slopes, eroded
ZaD2	Zanesville silt loam	12 to 20 percent slopes, eroded

Source: Soil Survey: Jefferson County, Kentucky, US Department of Agriculture Soil Conservation Service (June 1966).

Source: Soil Survey: Jefferson County, Kentucky, US
Department of Agriculture Soil Conservation Service (June 1966).

Louisville Metro Landslide History

No reports are available from USGS, NWS, NCDC, SHELDUS, or the State Mitigation Plan for landslide incidences. However, Louisville Metro has experienced landslides and slope failure affecting roads and infrastructure items. During the planning process, community members and community officials identified slope failure areas that have repeat occurrences.

- Louisville Metro Public Works reports two properties along Pine Mountain Road were acquired due to landslides; with estimated losses at around $150,000 each or $300,000 total.
- Public Works reports several properties (~60) along Cardinal Hill show signs of under-pinning.
- EMA reports, after the severe storm of 2003, 2 properties experienced minor to major landslide damage.
- Reports of landslides in Iroquois park, around Mitchell Hill, are commonly known for eroding.
- Geologic experts provided data of landslide events on Louisville Metro's highways (See Risk Score Map).

4.10.3. Assessing Vulnerability Overview

Landslide Vulnerability Score = Exposure Score X Risk Score

Risk Score = Geographic Extent Score x Occurrence Score

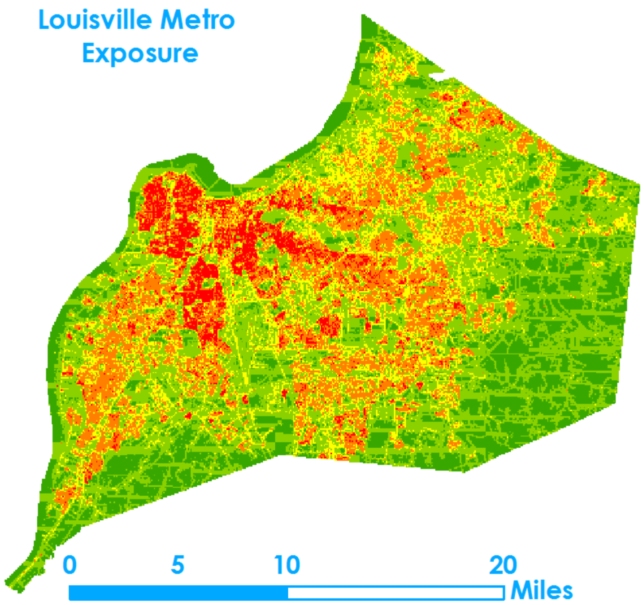
Geographic Extent = landslide risk of each grid cell based on KGS earthquake data. Landslide risk values were determined by Zhenming Wang (KGS) study of earthquake vulnerability. Risk values based on earthquake induced landslide potential under wet conditions were assigned to each grid cell and then a 0-1 score was calculated for each cell.

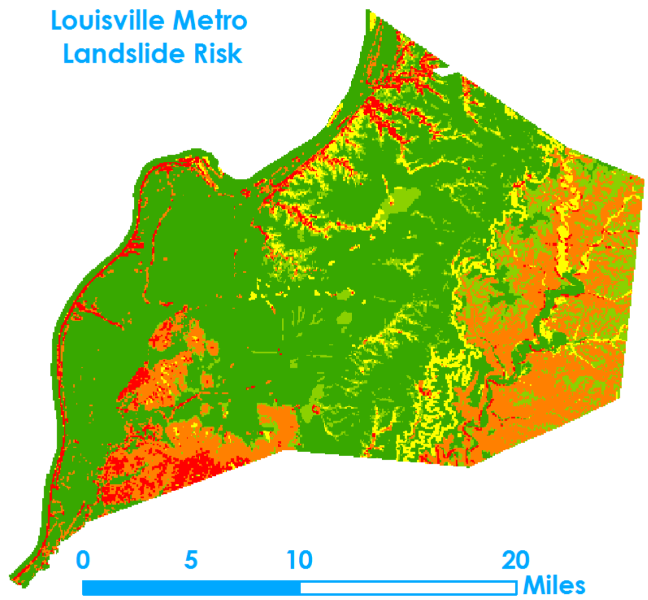
Occurrence Score – landslide occurrences. Occurrences were totaled for each grid cell and a 0-1 was calculated.

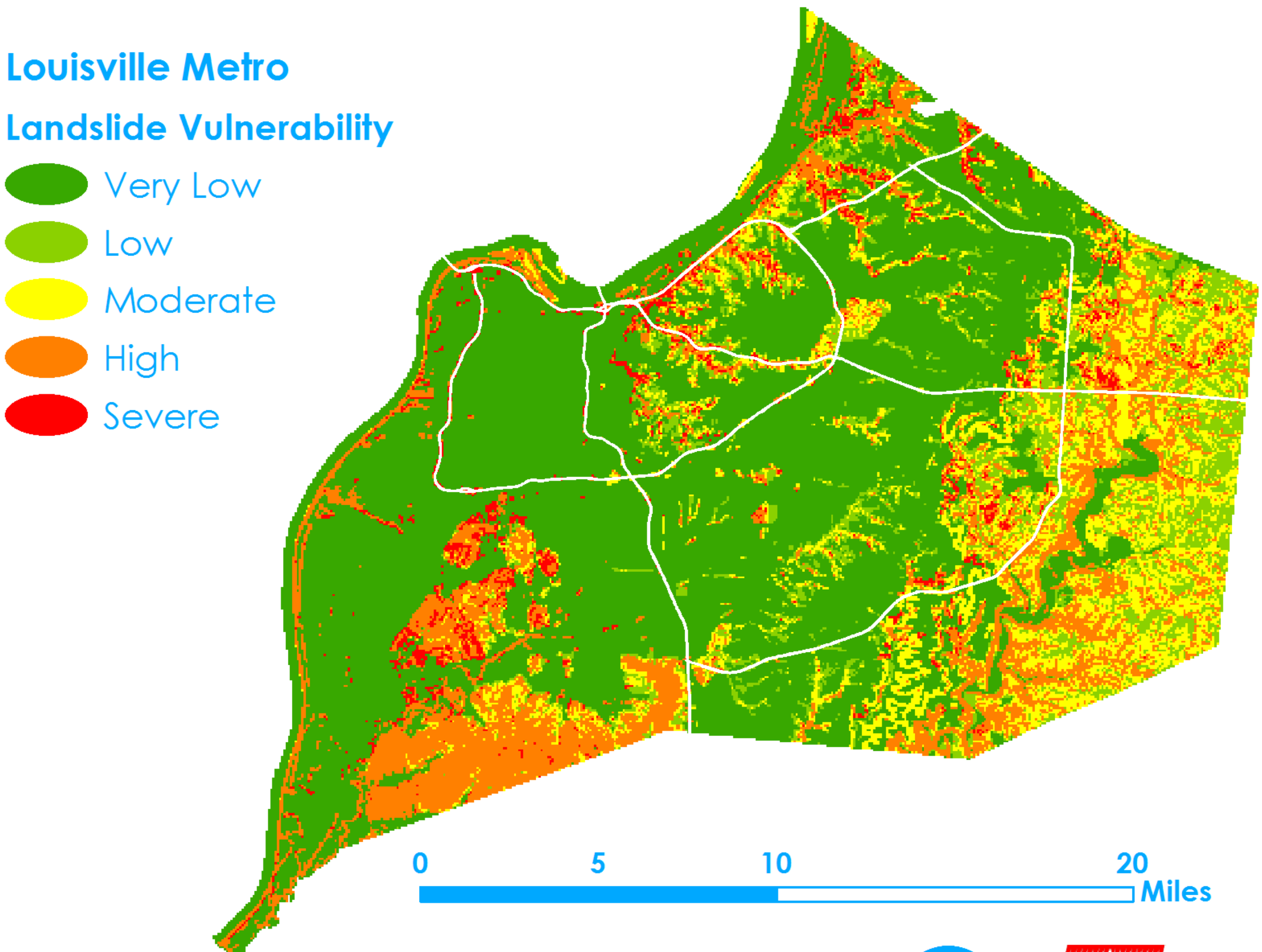
Occurrence score was added to geographic extent score and total was rescored 0-1.

The Landslide Risk Score and the Exposure score were added together and a new 0-1 score was calculated to give the final Landslide Vulnerability Score (Figure 12).

Figure 12. Landslide Hazard Vulnerability Map







Sources: LOJIC, Louisville MSD, US Census Bureau, Louisville EMA, Louisville Water Company, LG&E/KU, National Weather Service, Kentucky Geological Survey, Jefferson County PVA

4.11. Hazardous Materials

4.11.1. Identify: HazMat

Hazardous materials (HazMat) are solids, liquids, or gases that can harm people, other living organisms, property, or the environment and they are often subject to chemical regulations. "HazMat teams" are personnel specially trained to handle dangerous goods.

Hazardous materials are often indicated by diamond-shaped signage. The colors of each diamond in a way has reference to its hazard i.e.: Flammable = red, Explosive = orange, because mixing red (flammable) with yellow (oxidizing agent) creates orange. Non Flammable Non Toxic Gas = green.

HazMat Sources

Hazardous materials include materials that are radioactive, flammable, explosive, corrosive, oxidizing, asphyxiating, biohazardous, toxic, pathogenic, or allergenic. Also included are physical conditions such as compressed gases and liquids or hot materials, including all goods containing such materials or chemicals, or may have other characteristics that render them hazardous in specific circumstances.

Chemical manufacturers are one source of hazardous materials, but there are many others, including service stations, hospitals, and hazardous materials waste sites. Varying quantities of hazardous materials are manufactured, used, or stored at an estimated 4.5 million facilities in the United States--from major industrial plants to local dry cleaning establishments or gardening supply stores.

HazMat Impacts

Hazardous materials in various forms can cause death, serious injury, long-lasting health effects, and damage to buildings, homes, and other property. Many products containing hazardous chemicals are routinely used and stored in homes. These products are also shipped daily on the nation's highways, railroads, waterways, and pipelines.

Hazardous materials planning occurs per the requirements of Title III of the Super Fund Amendments and Reauthorization Act (SARA) of 1986, Comprehensive Environmental Response Compensation and Liability Act (CERCLA) of 1980 and EPA Clean Air Act of 1990, RMP, as provided for in Section 112(r).

Mitigating the risks associated with hazardous materials may require the application of safety precautions during their transport, use, storage and disposal. Laws and regulations on the use and handling of hazardous materials may differ depending on the activity and status of the material. For example, one set of requirements may apply to their use in the workplace while a different set of requirements may apply to spill response, sale for consumer use, or transportation.

4.11.2. Hazardous Materials Profile

Profile Risk Table	
Period of occurrence:	Anytime
Number of events:	1,179 (2010-2015)
Probability of events:	196.5
Past Damages	N/A
Warning time:	Minutes to hours
Potential impact:	Impacts human life, health, and public safety. Mass evacuations and potential surge medical events.
Potential of injury or death:	HazMat has a moderate potential for injury or death in Louisville
Possible Extent:	February 1981 – Ralston-Purina was responsible for a series of explosions in Louisville's sewer system, causing damages to roadways, vehicles, and homes in the area of Old Louisville. Over $20million was awarded in damages.

Industrial community hazardous materials can be found almost anywhere and releases of the materials into the environment can be deadly events. These releases can occur at almost any time, but in conjunction with another natural disaster such as a flood or earthquake the damages can multiply exponentially.

Louisville HazMat History

In the late 1970s and early 1980s, MSD was at the center of several serious hazardous material incidents that gained regional and national media attention. In 1985, the governments of both the City of Louisville and Jefferson County adopted an Ordinance requiring the submittal of a Hazardous Materials Use and Spill Prevention Control (HMPC) Plan by any business that manufactures, uses, or stores hazardous materials in excess of designated quantities. The HMPC plan must state how a business will respond to spills or discharges of these materials. The Ordinance also directs the MSD to administer and enforce the program.

The current Louisville Metro Hazardous Materials Ordinance was approved on July 2, 2007 as Ordinance No. 121, Series 2007 which amended and re-enacted Chapter 95 of the Louisville Metro Code of Ordinances. The purpose of the ordinance is for the protection of public health and safety through the prevention and control of hazardous materials incidents and releases and to require the timely reporting of releases. The MSD was designated as the lead agency in administering the ordinance.

The following event detail information summarizes Louisville's significant HazMat events.

March 17, 1977

"Hexa" and "Octa" Event: employees at the Morris Forman water treatment plant noticed a strong, chemical odor that made them sick. It was the beginning of an environmental incident that would set legal precedent in the United States. It took more than a week to identify the highly toxic chemicals used in pesticides as a mixture of hexachloropentadiene and octachlorocyclopentene, quickly abbreviated to "hexa" and "octa." The contaminated treatment plant was shut down on March 29th, discharging 100 million gallons of untreated wastewater into the river each day.

The U.S. Army sent teams wearing protective gear into the sewers to find the source of the chemicals and the FBI joined the investigation. June 7th, a federal grand jury charged Donald E. Distler, president of Kentucky Liquid Recycling, and two of his employees with dumping toxic chemicals into the sewers. The chemicals were wastes that had been sent to Distler's company for disposal and Distler's company dumped them down a manhole in western Louisville.

The treatment plant was shut down for nearly three months while the contaminated material was removed — three months of discharging all the raw sewage into the river. It took another two years to remove the contaminated material from the sewer lines — years during which the raw sewage from these lines was shunted around the plant and into the river.

In September, 1979, the month the cleanup ended, Distler was found guilty — the first time an individual was convicted in a trial of federal criminal charges of polluting a waterway. He was sentenced to two years in prison and fined $50,000. After appealing all the way to the U.S. Supreme Court, he was sent to prison in early 1982.

In January, 1983, the companies that had originated the waste — Velsicol Chemical Corp. of Chicago and Chem-Dyne Corp. of Hamilton, Ohio — agreed to pay MSD $1.9 million for the medical costs of employees and the costs of cleaning up the sewers and the treatment plant.

February 13, 1981

The Sewer Explosions - two women going to work at a hospital drove under the railroad overpass on Hill Street near 12th Street when there was a gigantic blast, and their car was hurled into the air and onto its side. At the same time, a police helicopter was heading toward the downtown area when the officers saw an unforgettable sight: a series of explosions, "like a bombing run," erupting along the streets of Old Louisville and through the University of Louisville campus.

More than two miles of Louisville streets were pockmarked with craters where manholes had been and several blocks of Hill Street had fallen into the collapsed, 12-foot-diameter sewer line. Miraculously, no one was hurt seriously, but homes and businesses were extensively damaged and some families had to be evacuated. Louisville was in the headlines and on broadcast news throughout the country for several days.

The cause of the explosion was traced to the Ralston-Purina soybean processing plant southeast of the university campus, where thousands of gallons of a highly flammable solvent, hexane, had spilled into the sewer lines. The fumes from the hexane created an explosive mixture, which lay in wait in the larger sewer lines. As the women drove under the overpass, a spark from their car apparently ignited the gases.

Several blocks of Hill Street soon became an open trench, as crews cleared away the debris and prepared to replace the sewer line. The trench remained open throughout the summer while work continued. It took 20 months to repair the sewer lines, and another several months to finish the work on the streets.

Ralston-Purina pleaded guilty of four counts of violating federal environmental laws, and paid a fine of $62,500. In February, 1984, the company agreed to pay MSD more than $18 million in damages. Many millions more were paid to other government agencies and private individuals who suffered damage.

4.11.3. Assessing Vulnerability: HazMat

HazMat Vulnerability Score = Exposure Score + Risk Score

Risk Score = Geographic Extent Score + Occurrence Score

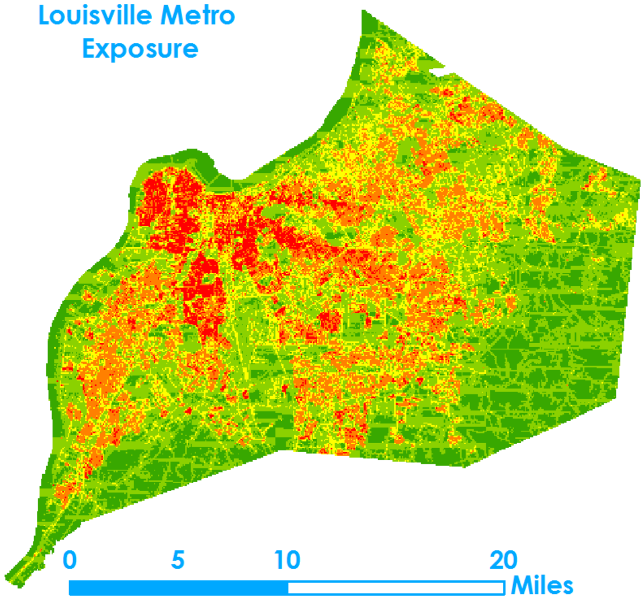
Geographic Extent = The number of rail lines, interstate highways, expressways, ramps, and major arterials were identified within one mile of each grid cell. The total count for each cell was converted to 0-1 score.

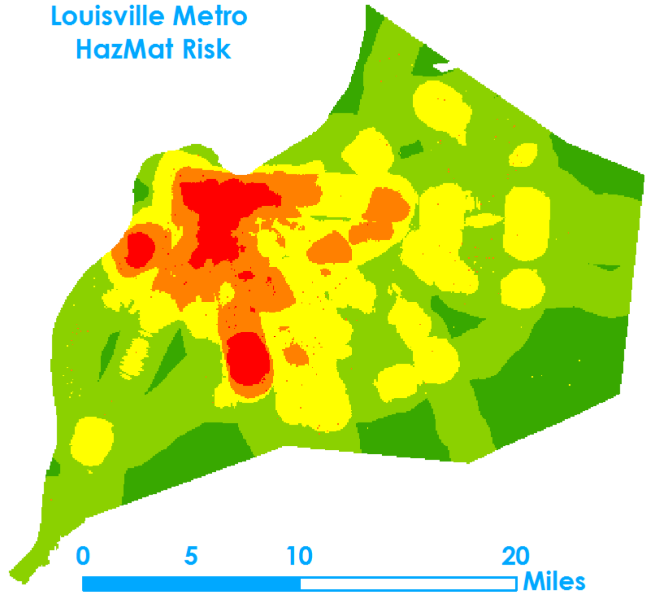
Occurrence Score = The number of facilities with hazardous materials in each grid cell. Locations of facilities with hazardous materials were obtained from Louisville Metro EMA. The total number of facilities was converted to 0-1 score for each cell.

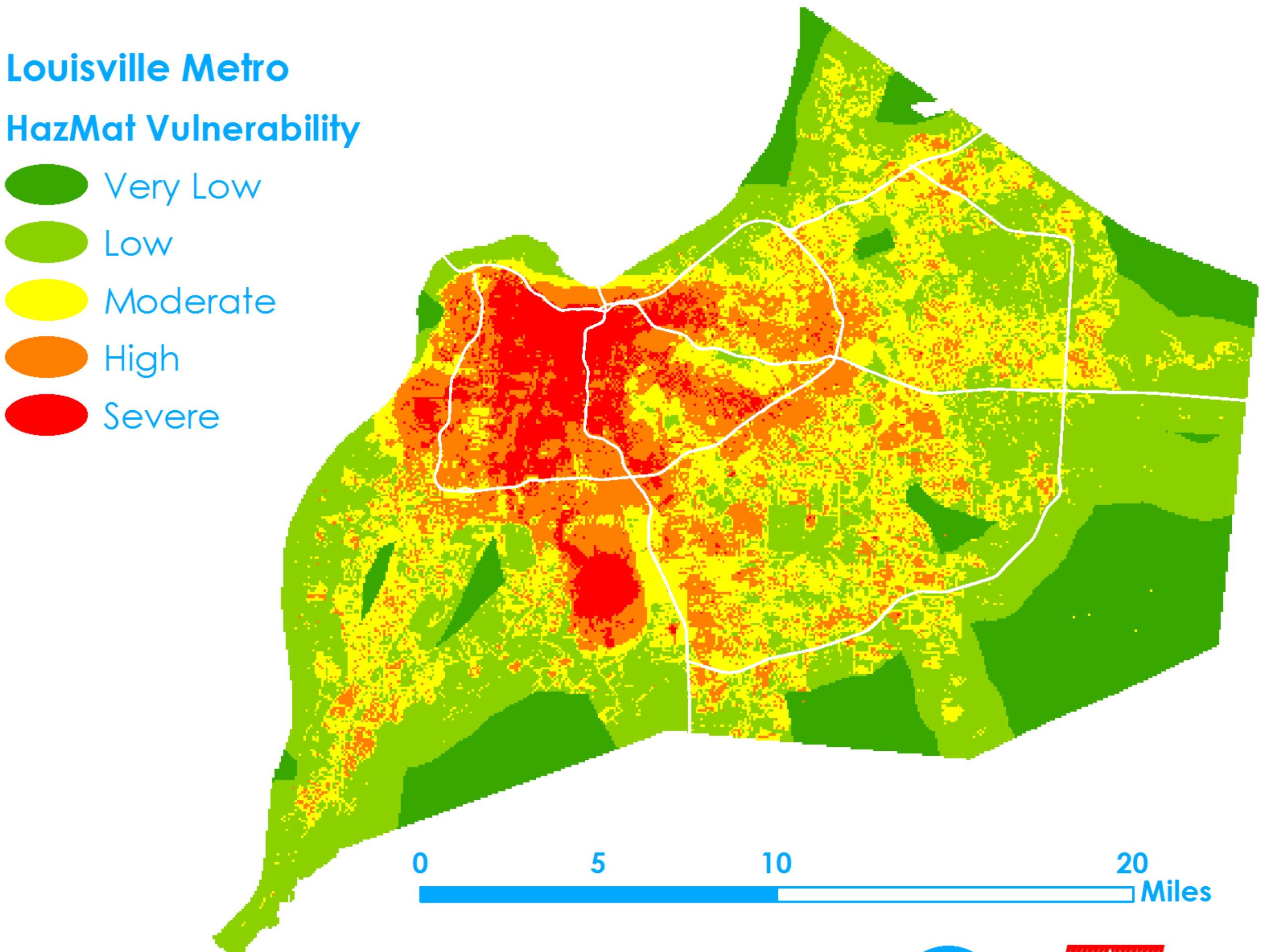
Geographic Extent Score was added to Occurrence Score and the total was converted to 0-1, resulting in the HasMat Risk Score.

The HazMat Risk Score and the Exposure score were added together and a new 0-1 score was calculated to give the final HazMat Vulnerability Score (Figure 13).

Figure 13. HazMat Hazard Vulnerability Map







Sources: LOJIC, Louisville MSD, US Census Bureau, Louisville EMA, Louisville Water Company, LG&E/KU, National Weather Service, Kentucky Geological Survey, Jefferson County PVA

4.12. Drought

4.12.1. Identify: Drought

A drought is defined as the cumulative deficit of precipitation relative to what is normal for a region over an extended period of time. Unlike other natural hazards, a drought is a non-event that evolves as a prolonged dry spell. Droughts occur when a long period passes without substantial rainfall. A heat wave combined with a drought is a very dangerous situation.

When a drought begins or ends may be difficult to determine. A drought can be short, lasting just a few months, or persist for years before climatic conditions return to normal. While drought conditions can occur at any time throughout the year, the most apparent time is during the summer months. High temperatures, prolonged high winds, and low relative humidity can aggravate drought conditions.

Because the impacts of a drought accumulate slowly at first, a drought may not be recognized until it has become well established. The many aspects of drought reflect its varied impacts on people and the environment. While the impacts of precipitation deficit may be extensive, it is the deficit, not the impacts, that defines a meteorological drought.

Primary Effects

- Crop failure is the most apparent effect of drought in that it has a direct impact on the economy and, in many cases, health (nutrition) of the population that is affected by it. Due to a lack of water and moisture in the soil, many crops will not produce normally or efficiently and, in many cases, may be lost entirely.
- Water shortage is a very serious effect of drought in that the availability of potable water is severely decreased when drought conditions persist. Springs, wells, streams, and reservoirs have been known to run dry due to the decrease in ground water, and, in extreme cases, navigable rivers have become unsafe for navigation as a result of drought.

Secondary Effects

- Fire susceptibility is increased with the absence of moisture associated with a drought. Dry conditions have been known to promote the occurrence of widespread wildfires.

Tertiary Effects

- Environmental degradation in the forms of erosion and ecological damage can be seen in cases of drought. As moisture in topsoil decreases and the ground becomes dryer, the susceptibility to windblown erosion increases. In prolonged drought situations, forest root systems can be damaged and/or destroyed resulting in loss of habitat for certain species. In addition, prolonged drought conditions may result in loss of food sources for certain species.
- In prolonged drought situations the soil surrounding structures subsides, sometimes creating cracks in foundations and separation of foundations from above ground portions of the structure.

The Palmer Drought Severity Index (PDSI) shows the relative dryness or wetness effecting water sensitive economies. The PDSI indicates the prolonged and abnormal moisture deficiency or excess.

The PDSI is an important climatological tool for evaluating the scope, severity, and frequency of prolonged periods of abnormally dry or wet weather. It can be used to help delineate disaster areas and indicate the availability of irrigation water supplies, reservoir levels, range conditions, amount of stock water, and potential intensity of forest fires.

Palmer Drought Classifications System	
-2.0 in to -2.99 in	Moderate drought
-3.0 in to -3.99 in	Severe drought
-4.0 in or less	Extreme drought

Source: National Oceanic and Atmospheric Association (NOAA)

Climate histories generally begin in 1895. Drought is measured in the PDSI according to the level of recorded precipitation against the average, or normal, amount of precipitation for a region.

Despite all of the problems that droughts cause, drought has proven to be difficult to define. There is no universally accepted definition because drought, unlike flooding for example, is not a distinct event. Additionally, drought is often the result of many complex factors and has no well-defined start or end. The impacts of drought may again vary by affected sector, thus making definitions of drought specific to particular situations.

The most commonly used drought definitions are based on meteorological, agricultural, hydrological, and socioeconomic effects.

- Meteorological drought is defined as a period of substantially diminished precipitation duration or intensity. The commonly used definition of meteorological drought is an interval of time, generally on the order of months or years, during which the actual moisture supply at a given place consistently falls below the climatically appropriate moisture supply.
- Agricultural drought occurs when there is inadequate soil moisture to meet the needs of a particular crop at a particular time. Agricultural drought usually occurs after or during meteorological drought but before hydrological drought. It can also affect livestock and other dry-land agricultural operations.
- Hydrological drought refers to deficiencies in surface and subsurface water supplies. There is usually a delay between lack of rain or snow and less measurable water in streams, lakes, and reservoirs. Therefore, hydrological measurements tend to lag other drought indicators.
- Socioeconomic drought occurs when physical water shortages start to affect the health, well-being, and quality of life of the people, or when the drought begins to affect the supply and demand of an economic product.

4.12.2. Drought Profile

Profile Risk Table	
Period of occurrence:	Summer months or extended periods of no precipitation.
Number of events:	32 (1945-2015)
Probability of events:	.45
Past Damages	N/A
Warning time:	Weeks
Potential impact:	Activities that rely heavily on high water usage may be impacted significantly, including agriculture, tourism, wildlife protection, municipal water usage, commerce, recreation, electric power generation, and water quality deterioration. Droughts can lead to economic losses such as unemployment, decreased land values, and Agro-business losses. Minimal risk of damage or cracking to structural foundations, due to soils.
Potential of injury or death:	Drought has a low potential for injury or death in Louisville
Possible Extent:	59 months from May 1952 until April 1957

Kentucky Drought Action Levels

Drought Advisories:

- Drought Level I: "Official" recognition of drought
- Drought Level II: Serious impacts to human / environment
- Drought Level III: Substantial impacts to human / environment

A Level 1 drought indicates moderate drought conditions have developed primarily affecting soil moisture and vegetative health. Serious impacts to agricultural water needs, an increased wildfire risk, water supply shortages with systems on small lakes and reservoirs, and other water-sensitive sectors can be expected in the designated areas.

A Drought Level I declaration will be considered when at least three of the five indicators meet the trigger threshold. At this stage of drought it is expected that some level of drought impact will be observed in one or more drought management regions.

A Level 2 drought indicates that the Level 1 risks are becoming an actuality. Low stream flows and lower-than-normal lake levels could lead to water conservation advisories and/or mandatory restrictions on water use.

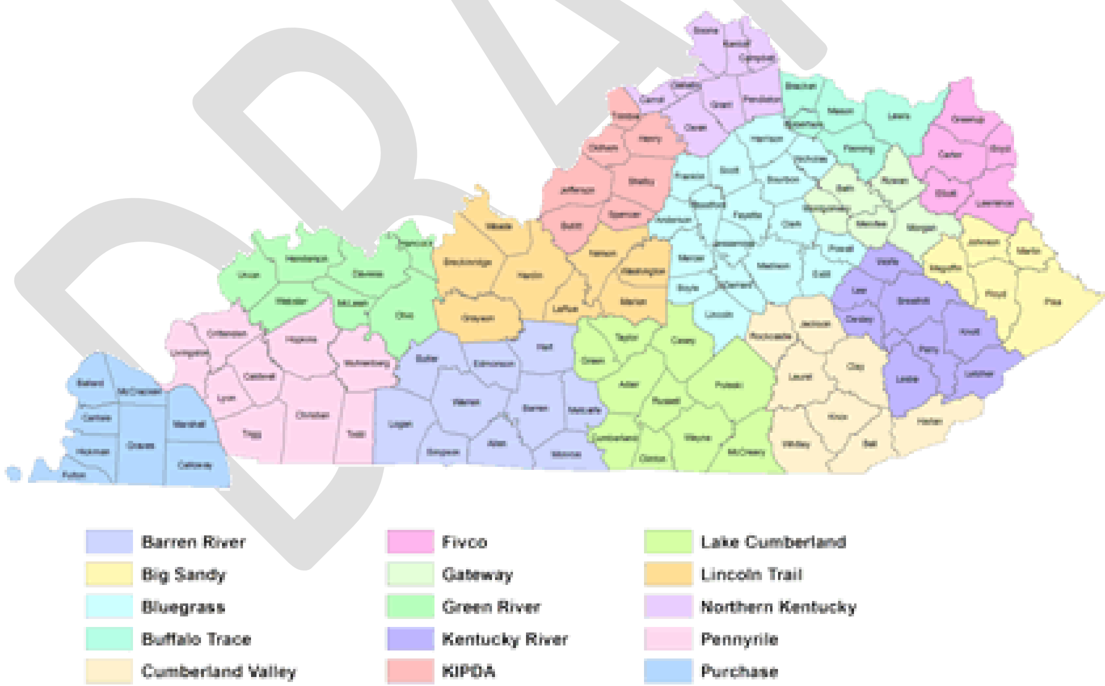
A Drought Level II declaration will be considered when at least three of the five indicators meet the trigger threshold. At this stage of drought it is expected that drought impacts, some severe, will be observed in all of the affected drought management regions including:

- Moderate to severe impacts to water-sensitive enterprises
- Unusually high demands placed on water treatment facilities
- Depletion of water supplies in shallow wells, springs and small ponds
- Reports of water conservation advisories from communities with drought-vulnerable sources of supply
- Increased incidence wildland and residential fires

A Drought Level III declaration will be considered when at least three of the five indicators meet the trigger threshold. During this stage of drought it is expected that drought impacts will be widespread and severe and develop into emergencies if drought conditions are not abated, including:

- Severe to extreme impacts to water-sensitive enterprises
- Loss of water supplies in shallow wells, springs and small ponds
- Multiple occurrences of water utilities requiring mandatory water-use restrictions or declaring local water shortage emergencies
- Critical low streamflows impacting water quality and aquatic habitat
- Frequent reports of water utilities having difficulties with adequate treatment for iron or manganese, or with taste and odor problems
- Critically low flows in some major rivers that provide drinking water to large population centers in the drought management regions
- Increased incidence of conflicts between users of diminishing water resources
- Increased incidence wildland and residential fires

The Kentucky Division of Water continuously monitors hydrologic conditions throughout the state, including precipitation, streamflows, lake elevations and various drought indices. This information is used to detect emerging drought conditions, to identify the locations and severity of drought and to provide timely and appropriate public notification. For purposes of drought planning and response, the state is divided up to 15 Drought Management Regions that are based upon the Area Development Districts. Each district is monitored individually to better determine which areas of the state are being impacted and allow a more focused response to those who are being affected.



Louisville Metro Drought History

Louisville experienced 32 droughts from 1945 through 2015. The longest drought was 59 months from May 1952 until April 1957. The average duration of drought for Louisville is eight months. National Drought Mitigation Center Drought Risk Atlas

August - October 2007
Drought had firmly established itself in the southeastern U.S. by late spring 2007, and began swelling northward during the early summer. By mid-June southern Kentucky had entered a severe drought with precipitation deficits since January 1 on the order of eight inches.

The severe drought conditions continued to spread northward, and all of central Kentucky felt the effects by the end of June. The Commonwealth issued a Water Shortage Watch for 61 central Kentucky counties. Burn bans went into effect and the Green River Ferry in mammoth Cave National Park discontinued service because of low water levels. A few counties imposed water restrictions on residents. The Tennessee Valley Authority placed a fuel surcharge of $3 to $6 per month per customer on electricity.

During August, searing heat baked Kentucky, creating significant stress on agricultural concerns and water supplies. Temperatures soaring into the 90s nearly every day and over 100 degrees on several occasions, combined with continued low overall rainfall amounts, locked the region firmly in drought. By the third week of the month roughly the southern half of Kentucky had descended into extreme drought, with severe drought conditions crossing the Ohio River into southern Indiana. People from Logan County to Nelson County to Casey County were about sixteen inches below normal for rainfall since the beginning of the year.

The number of wildfires in Kentucky increased 500% over the previous summer. In southern Kentucky soil moisture was about half of what it should have been, and 17 counties became eligible for Federal aid. The Barren River at Bowling Green was at its lowest point since the Barren River Dam was erected in 1963.

October 2010
A drought declaration was issued for 50 counties in seven DMAs under a Level 2 declaration and 35 counties in eight DMAs under a Level 1 declaration with agricultural disasters and wildfires becoming a major concern. As of October 12, 38 Kentucky counties were under burn bans. See graphic/map for 2010 Drought Action Levels provided by KDOW.

Drought Potential Impacts
High temperatures, prolonged high winds, and low relative humidity can aggravate drought conditions. In Louisville Metro, a secondary effect of a drought could be low river levels on the Ohio River. Low water can become unsafe for navigation in some areas. As a result, fully loaded barges may not be able to safely navigate the river, and tonnage may have to be reduced by 10 to 20 percent.

Drought can impact the following:
- Agriculture - irrigation and livestock needs
- Drinking Water
- Industrial use
- Power generation
- Water Quality - effluent dominated streams
- Human Health Impacts - heat and airborne particulates
- Environmental Damage - erosion, habitat loss
- Wildfires
- Structure and Infrastructure - water lines and foundations

During periods of drought, some activities that rely heavily on high water usage may be impacted significantly. These activities include agriculture, tourism, wildlife protection, municipal water usage, commerce, recreation, wildlife preservation, electric power generation, and water quality deterioration.
Droughts can lead to economic losses such as unemployment, decreased land values, and Agro-business losses. In addition, there is minimal risk of damage or cracking to structural foundations, due to soils.

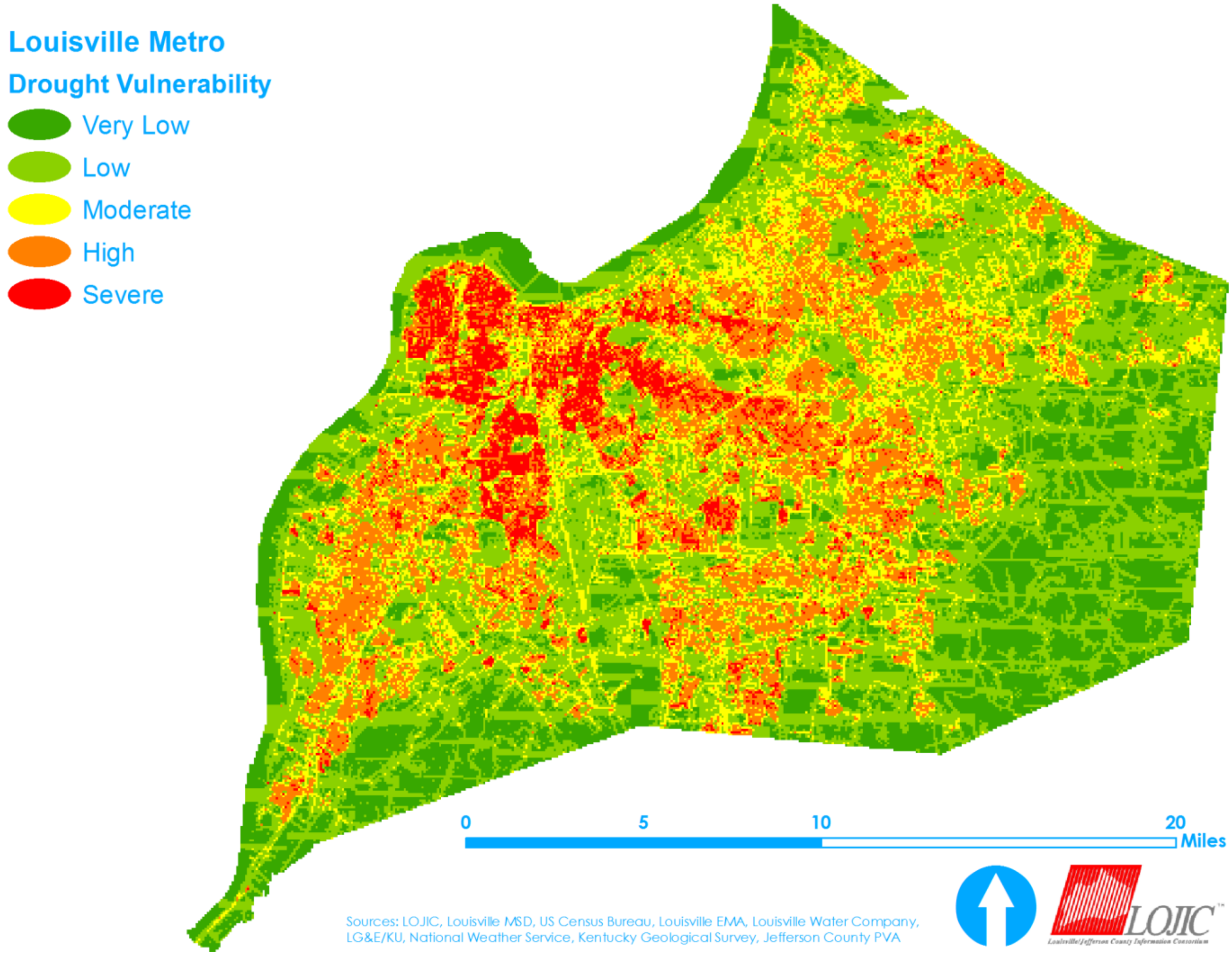
4.12.3. Assessing Vulnerability Overview

Drought Vulnerability Score = Exposure Score

The Drought Vulnerability Score is currently difficult to calculate. Currently Louisville Metro has no real spatial data that can be calculated to determine vulnerable areas to drought. Drought is the type of hazard that typically affects a county the size of Louisville Metro equally. With that being said it was determined to use the following Exposure Score map to display the Drought Vulnerability Score based on the assumption that the entire county is equally vulnerable to Drought.

The Exposure Score provides a visual display of areas that could be harder hit by drought based on the exposure that is within each grid cell (Figure 14).

Figure 14. Drought Hazard Vulnerability Map



4.13. Extreme Heat

4.13.1. Identify: Extreme Heat

Temperatures that hover 10 degrees or more above the average high temperature for the region and last for several weeks are defined as extreme heat.

Heat is the number one weather-related killer in the U.S. The NWS statistical data shows that heat causes more fatalities per year than floods, lightning, tornadoes, and hurricanes combined.

In the disastrous heat wave of 1980, more than 1,250 people died in the U.S. In addition the heat wave of 1995 more than 700 deaths in the Chicago area were attributed to heat. During the last two weeks of July 1999, the Midwest experienced a lengthy series of days with temperatures in excess of 90F. Before it was over, some 232 deaths were attributed to the heat in the 9-state Midwest region.

Our bodies dissipate heat by varying the rate and depth of blood circulation, by losing water through the skin and sweat glands, and as a last resort, by panting, when blood is heated above 98.6°F. Sweating cools the body through evaporation. However, high relative humidity retards evaporation, robbing the body of its ability to cool itself.

NOAA's Watch, Warning, and Advisory Products for Extreme Heat

Each NWS Weather Forecast Office can issue the following heat-related products as conditions warrant:

- Excessive Heat Outlooks are issued when the potential exists for an excessive heat event in the next 3-7 days. An Outlook provides information to those who need considerable lead time to prepare for the event, such as public utilities, emergency management, and public health officials.

- Excessive Heat Watch is issued when conditions are favorable for an excessive heat event in the next 12 to 48 hours. A Watch is used when the risk of a heat wave has increased, but its occurrence and timing is still uncertain. A Watch provides enough lead time so those who need to prepare can do so, such as cities that have excessive heat event mitigation plans.

- Excessive Heat Warning/Advisory is issued when an excessive heat event is expected in the next 36 hours. These products are issued when an excessive heat event is occurring, is imminent, or has a very high probability of occurring. The warning is used for conditions posing a threat to life or property. An advisory is for less serious conditions that cause significant discomfort or inconvenience and, if caution is not taken, could lead to a threat to life and/or property.

As an example, if the air temperature is 96°F (top of the table) and the relative humidity is 65% (left of the table), the heat index--how hot it feels--is 121°F. The NWS will initiate alert procedures when the Heat Index is expected to exceed 105°- 110°F (depending on local climate) for at least 2 consecutive days.

Important: Since heat index values were devised for shady, light wind conditions, exposure to full sunshine can increase heat index values by up to 15°F.

Heat Index

The Heat Index Chart shown above indicates that temperatures exceeding 105°F may cause increasingly severe heat disorders with continued exposure and/or physical activity. Heat disorders generally have to do with a reduction or collapse of the body's ability to shed heat by circulatory changes and sweating or a chemical (salt) imbalance caused by too much sweating. When the body heats too quickly to cool itself safely, or when you lose much fluid or salt through dehydration or sweating, your body temperature rises and heat-related illness may develop.

Heat disorders share one common feature: the individual has been in the heat too long is exercised too much for his or her age and physical condition. Studies indicate that, other things being equal, the severity of heat disorders tend to increase with age. Conditions that cause heat cramps in a 17-year-old may result in heat exhaustion in someone 40, and heat stroke in a person over 60. Sunburn, with its ultraviolet radiation burns, can significantly retard the skin's ability to shed excess heat.

Heat Disorder Symptoms

- Sunburn: Redness and pain. In severe cases swelling of skin, blisters, fever, headaches. First Aid: Ointments for mild cases if blisters appear and do not break. If breaking occurs, apply dry sterile dressing. Serious, extensive cases should be seen by physician.

- Heat Cramps: Painful spasms usually in the muscles of legs and abdomen. Heavy sweating. First Aid: Firm pressure on cramping muscles or gentle massage to relieve spasm. Give sips of water. If nausea occurs, discontinue water.
- Heat Exhaustion: Heavy sweating, weakness, skin cold, pale and clammy. Pulse thready. Normal temperature possible. Fainting and vomiting. First Aid: Get victim out of sun. Once inside, the person should lay down and loosen clothing. Apply cool, wet cloths. Fan or move victim to air conditioned room. Offer sips of water. If nausea occurs, discontinue water. If vomiting continues, seek immediate medical attention.
- Heat Stroke (or sunstroke): High body temperature (106° F or higher). Hot dry skin. Rapid and strong pulse. Possible unconsciousness. First Aid: heat stroke is a severe medical emergency. Summon emergency medical assistance or get the victim to a hospital immediately. Delay can be fatal.

4.13.2. Profile: Extreme Heat

Profile Risk Table	
Period of occurrence:	May - September
Number of events:	3 (2011-2012)
Probability of events:	1.5
Past Damages	N/A
Warning time:	Days
Potential impact:	Extreme Heat can cause heat stroke and even death.
Potential of injury or death:	Extreme Heat has a high potential for injury or death in Louisville
Possible Extent:	2012 – 86 estimated heat related deaths (Louisville Urban Heat Management Study)

Temperatures that hover 10 degrees or more above the averaoge high temperature for the region are defined by NOAA as extreme heat. A temperature of 90°F is significant in that it ranks at the "caution" level of the NOAA's Apparent Temperature chart even if humidity is not a factor.

Kentucky Historical Impact

The 1952 heat wave lacked the intensity of other heat waves but it did have duration. According to the Kentucky Division of Forestry, numerous acres burned in 1952 due to the lack of precipitation. In Louisville alone, there was not a single day below the average temperature.

1990 and 1991 saw consecutive heat waves in which 1991 caused a statewide drought. 1991 is the third warmest year on record and also contained the third warmest summer as well as the second warmest spring.

The average temperature for August in Kentucky is around 77 degrees, give or take a few points per location. In 2007, the average was 85 degrees. During 2007, there were 67 days of temperatures over 90 degrees and 5 reaching over 100 degrees recorded. A federal disaster designation by the U.S. Department of Agriculture was declared allowing farmers in the state's $4 billion-a-year industry to seek emergency assistance, including low-interest loans to help pay for essential farm and living expenses.

History of Extreme Heat in Louisville Metro

Research has shown there is limited Louisville Metro data for tracking the damages, injuries, or deaths for extreme heat. Death certificates kept by the Jefferson County Health Department show six deaths due to extreme heat occurred during 1999 - 2002. These deaths occurred as following: four in 1999, 1 in 2000, and 1 in 2002. Other Extreme Events include:

July 1999

During the last two weeks of July 1999, the Midwest experienced a lengthy series of days with temperatures higher than 90 degrees F. While only a relatively small number of maximum temperature records were set, the combination of high heat, record dew points, strong solar inputs, and weak winds led to a dangerous situation for people. Before it was over, some 232 deaths were attributed to the heat in the 9-state area served by the MRCC; there were additional health, infrastructure, and economic impacts that were quite significant.

The major loss of life was in large cities where the urban heat island amplified temperatures by 3 to 5 degrees or more. The majority of those who died were elderly persons, living alone in the inner city regions, and either were without air conditioning or without the funds to pay for continuous operation of their air conditioning units. Most of the people who died on the 29th and 30th lived in large cities with an old infrastructure of non-air-conditioned brick buildings.

August 2007
Nearly 30 temperature records were set in central Kentucky in August 2007, including 105 degrees at Louisville on the 16th which tied the all-time record for the month. Louisville set a new record for consecutive 90 degree days (22). August 2007 became the hottest month ever recorded at Louisville and Bowling Green, and the 3rd hottest on record at Lexington.

Summer 2010 (June-July-August)
The hottest on record for Louisville. This is true with respect to both AVERAGE temperature and MINIMUM daily temperature. The summer was the 2nd warmest on record with MAXIMUM daily temperature (1952 had higher maximum temps).

Table 9 shows the NWS' overview of Louisville's average, maximum, and minimum temperatures from 1981 - 2010.

Table 9. Monthly Normal Temperatures

Month	Max Temp	Min Temp	Average Temp
January	43.0	26.8	34.9
February	47.8	29.9	38.8
Winter	45.5	28.9	37.2
March	57.9	37.8	47.8
April	68.8	47.3	58.0
May	77.1	57.0	67.1
Spring	67.9	47.4	57.6
June	85.3	66.0	75.6
July	88.7	69.9	79.3
August	88.3	68.5	78.4
Summer	87.5	68.1	77.8
September	81.5	60.5	71.0
October	70.1	48.9	59.5
November	57.9	39.5	48.7
Autumn	69.8	49.6	59.7
December	45.8	30.0	37.9
Annual	67.8	48.6	58.2

Extreme Heat Impacts
Main impacts are to public health and safety, especially the elderly. Additionally, heavy use of utilities (electric and water) cause a strain on the system due to air conditioners, fans, and water usage, etc…

4.13.3. Assessing Vulnerability: Extreme Heat

Extreme Heat Vulnerability Score = Exposure Score + Risk Score

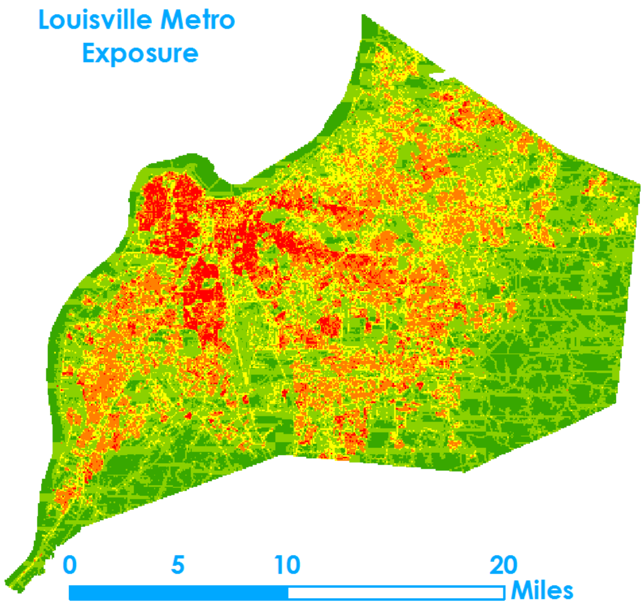
Risk Score = Geographic Extent Score + Occurrence Score

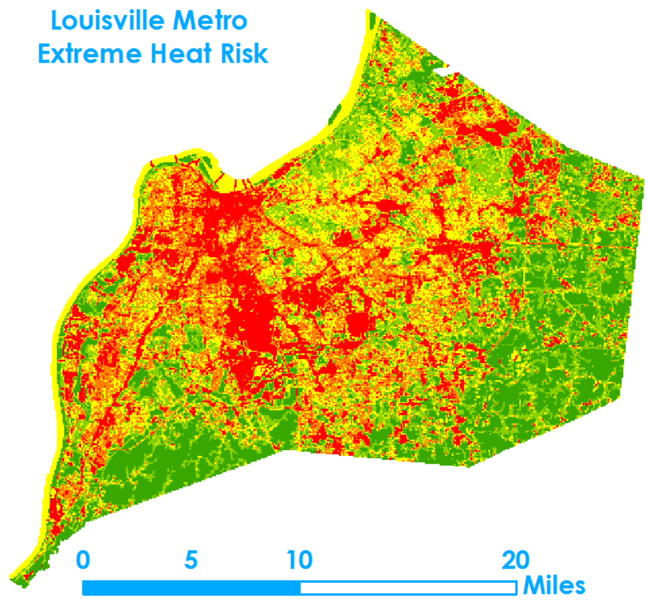
The Geographic Extent Score was determined by assigning near surface air temperatures to each grid cells. Near surface air temperatures were modeled for the Urban Heat Management Study by the Urban Climate Lab of the Georgia Institute of Technology. Temperatures levels for each grid cell were converted to a 0-1 score.

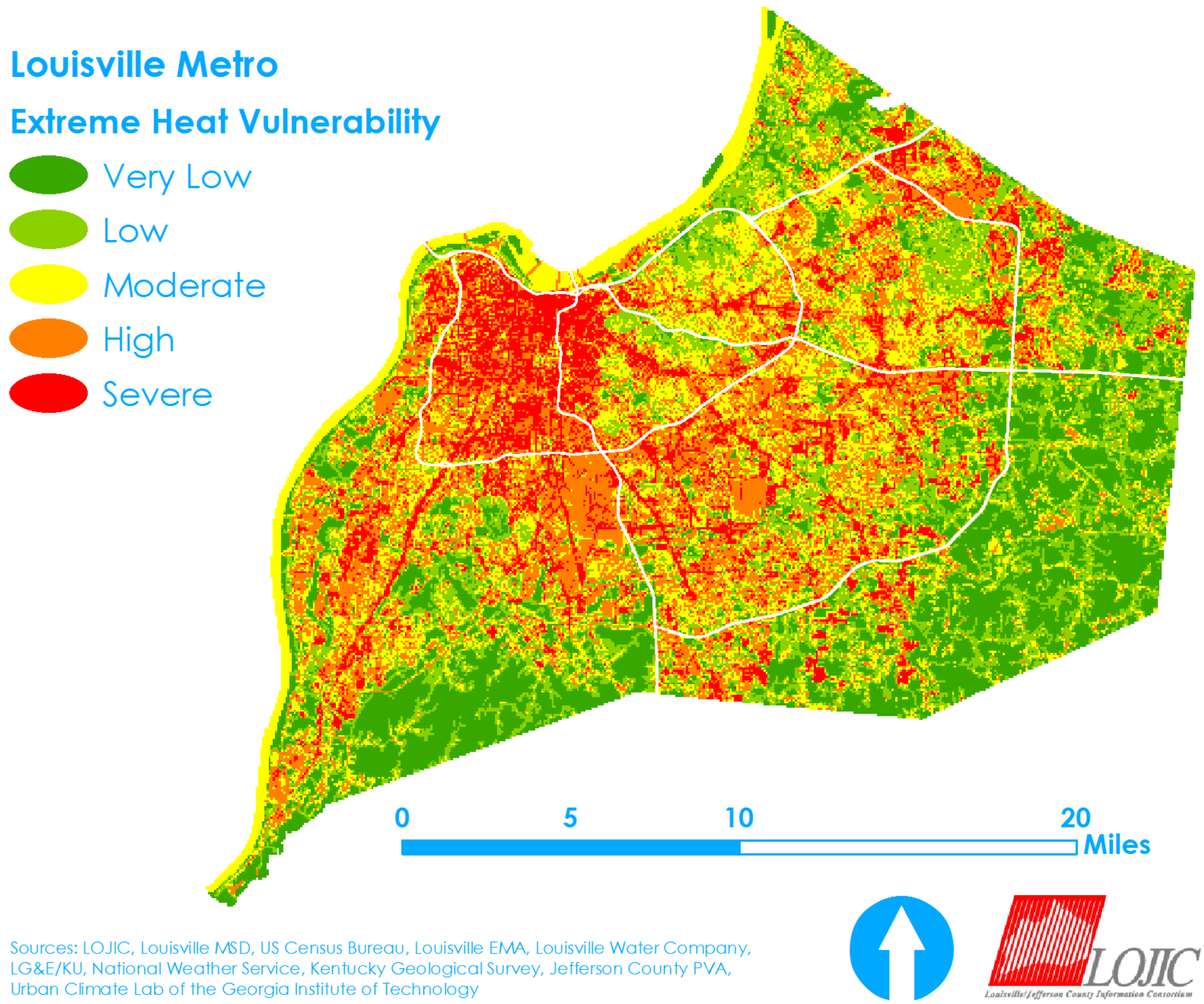
The Occurrence Score was determined by assigning estimated heat related deaths in 2012 to each grid cell. The heat related deaths were estimated for the Urban Heat Management Study by the Urban Climate Lab of the Georgia Institute of Technology. Heat related deaths were estimated through the application of a heat risk factor derived from a study of temperature and mortality rates from all causes over time. By determining how many additional deaths result in the region for every one-degree increase in temperature, it is possible to estimate the number of heat-related deaths likely to occur on each day in the May through September warm season. Applying this approach, 86 residents of the Louisville Metro area are estimated to have died from a heat-related cause during the 2012 warm season.

The Occurrence Score was added to the Geographic Extent Score and the total was converted to a 0-1 score. The Risk Score and Exposure Score were then added together for each cell resulting in the Extreme Heat Vulnerability Score (Figure 15).

Figure 15. Extreme Heat Hazard Vulnerability Map







Sources: LOJIC, Louisville MSD, US Census Bureau, Louisville EMA, Louisville Water Company, LG&E/KU, National Weather Service, Kentucky Geological Survey, Jefferson County PVA, Urban Climate Lab of the Georgia Institute of Technology

4.14. Wildfires

4.14.1. Identify: Wildfires

A wildfire is an unplanned fire, which includes grass fires, forest fires, and scrub fires either man-made or natural in origin. There are three different classes of wildland fires. A wildfire is an uncontrolled burning of grasslands, brush, or woodlands.

Humans, either through negligence, accident, or intentional arson, have caused approximately 90% of all wildfires in the last decade. Accidental and negligent acts include unattended campfires, sparks, burning debris, and irresponsibly discarded cigarettes. The remaining 10% of fires are mostly caused by lightning, but may also be caused by other acts of nature such as volcanic eruptions or earthquakes.

Wildfires become significant threats to life and property along what is known as the "wildland/urban interface". The wildland/urban interface is defined as the area where structures and other human development meet or intermingle with undeveloped wild land or vegetative fuels.

The potential for wildfire depends upon surface fuel characteristics, weather conditions, recent climate conditions, topography, drought, and fire behavior. Weather is the most variable and impacts fire behavior most often. The main weather factors that have an effect on fire behavior are temperature, wind, and relative humidity. Wind increases the rate and the direction of fire spread. Relative humidity and temperature mainly affect fuel moisture. Changes in the weather, such as an approaching cold front, can greatly affect wind speed and direction, temperature and relative humidity, which in turn can greatly affect wildfire behavior. It is critical that firefighters understand the relationship of weather to fire behavior and keep abreast of any weather changes.

Fuels are anything that fire can and will burn, and are the combustible materials that sustain a wildfire. Typically, this is the most prevalent vegetation in a given area. Weather is one of the most significant factors in determining the severity of wildfires. The intensity of fires and the rate with which they spread is directly rated to the wind speed, temperature, and relative humidity. Climatic conditions such as long-term Drought Severe Winter Storm also play a major role in the number and intensity of wildfires, and topography is important because the slope and shape of the terrain can change the rate of speed at which fire travels.

Wildfire Types

- Surface fires are the most common type and burn along the floor of a forest, moving slowly and killing or damaging trees.
- Ground fires are usually started by lightning and burn on or below the forest floor.
- Crown fires spread rapidly by wind and move quickly by jumping along the tops of trees.
- Spotting can be produced by crown fires as well as wind and topography conditions. Large burning embers are thrown ahead of the main fire. Once spotting begins, the fire will be very difficult to control.

Wildfire Fuel Categories

- Light fuels such as shrubs, grasses, leaves, and pine needles (any fuel having a diameter of one-half inch or less) burn rapidly and are quickly ignited because they are surrounded by plenty of oxygen. Fires in light fuels spread rapidly but burn out quickly, are easily extinguished, and fuel moisture changes more rapidly than in heavier fuels.

- Heavy fuels such as limbs, logs, and tree trunks (any fuel one-half inch or larger in diameter) warm more slowly than light fuels, and the interiors are exposed to oxygen only after the outer portion is burned.
- Uniform fuels include all of the fuels distributed continuously over an area. Areas containing a network of fuels that connect with each other to provide a continuous path for a fire to spread are included in this category.
- Patchy fuels include all fuels distributed unevenly over an area, or as areas of fuel with definite breaks or barriers present, such as patches of rock outcroppings, bare ground, swamps, or areas where the dominant type of fuel is much less combustible.
- Ground fuels are all of the combustible materials lying beneath the surface including tree roots, rotten buried logs, and other organic material.
- Surface fuels are all of the combustible materials lying on or immediately above the ground, including needles or leaves, duff, grass, small deadwood, downed logs, stumps, large limbs, and low shrubs.
- Aerial fuels are all of the green and dead materials located in the upper canopy, including tree branches and crowns, snags, hanging moss, and tall shrubs.

Fuel Types

- Grass. Found in most areas, but grass is more dominant as a fuel in desert and range areas where other types of fuel are less prevalent. It can become prevalent in the years after a fire in formerly timbered areas.
- Shrub (brush). Shrub is found throughout most areas of the U.S. Some examples of highly flammable shrub fuels are the palmetto/ gallberry in the Southeast, sagebrush in the Great Basin, and chaparral in the Southwest.
- Timber litter. This type of fuel is most dominant in mountainous topography, especially in the Northwest.
- Logging slash. This fuel is found throughout the country. It is the debris left after logging, pruning, thinning, or shrub-cutting operations. It may include logs, chunks, bark, branches, stumps, and broken understory trees or shrubs.

Fuel Characteristics

Fuel moisture is the amount of water in a fuel. This measurement is expressed as a percentage. The higher the percentage, the greater the content of moisture within the fuel. How well a fuel will ignite and burn is dependent, largely, on its moisture content. Dry fuels will ignite and burn much more easily than the same fuels when they are wet (contain a high moisture content). As a fuel's moisture content increases, the amount of heat required to ignite and burn that fuel also increases.

Light fuels take on and lose moisture faster than heavier fuels. Wet fuels have high moisture content because of exposure to precipitation or high relative humidity, while dry fuels have low moisture content because of prolonged exposure to sunshine, dry winds, Severe Winter Storm, or low relative humidity.

4.14.2. Wildfire Profile

Profile Risk Table	
Period of occurrence:	Anytime, primarily Summer
Number of events:	6 (2000-2016)
Probability of events:	.35
Past Damages	N/A
Warning time:	None, unless related to drought. Humans, through negligence, accident, or intentional arson, have caused approximately 90% of all wildfires in the last decade.
Potential impact:	Impacts human life, health, and public safety. Loss of wildlife habitat, increased soil erosion, and degraded water quality. Utility damage and outages, infrastructure damage (transportation and communication systems), structural damage, damaged or destroyed critical facilities, and hazardous material releases.
Potential of injury or death:	Wildfires have a low potential for injury or death in Louisville
Possible Extent:	3 acre fire in 2010

Wildland fires have been occurring in Kentucky for thousands of years. Native Americans used fire to clear land for wildlife. Settlers moving into the state adopted the Native American land-clearing techniques, including the use of fire.

The Cumberland Plateau and the Appalachians in the eastern part of the state account for 50 percent of the state's forest cover, with 25 contiguous counties having a forest cover percentage of greater than 75 percent.

Oak-hickory is the dominant forest cover and covers 8.4 million acres, or 72 percent of the state's forested land. Oak-pine forests make up 9 percent, maple-beech-birch and aspen-birch make up 7 percent, oak-gum-cypress and elm-ash-cottonwood make up 6 percent, softwood makes up 5 percent, and non-stocked, 1 percent.

Private individuals own 78 percent of the timberland in Kentucky. Nine percent is public land administered by local, State, or federal agencies. Slightly more than one-half of the public timberland is managed by the U.S. Forest Service. Forest industry owns 2 percent of the timberland and other corporations account for the remaining 11 percent. The Division of Forestry owns and manages eight state forests - Tygarts, Green River, Pennyrile, Kentucky Ridge, Kentenia, Marrowbone, Knobs, and Rolleigh Peterson with a combined total of 39,401 acres.

The Division of Forestry is responsible for fighting wildland fires on private lands and enforcing forest fire hazard seasons and other outdoor burning regulations. The Division fights over 1,800 wildland fires annually. These fires burn more than 50,000 acres per year. The leading cause of forest fires in Kentucky is arson. Arson is the act of intentionally and/or maliciously setting a fire. Wildland arson is a serious crime that hurts all Kentuckians.

Kentucky's forest protection laws include penalties for intentionally setting a fire on land owned by another (KRS 149.380). The penalties for violating KRS 149.380 include a fine of not less than $1,000 or more than $10,000, imprisonment for not more than five years, or both fine and imprisonment.

Wildfire Potential Impact

Wildfire impacts human life, health, and public safety as well as a loss of wildlife habitat, increased soil erosion, and degraded water quality. Wildfire also can cause utility damage and outages, infrastructure damage (transportation and communication systems), structural damage, damaged or destroyed critical facilities, and hazardous material releases.

Because smoke from wildfires is a mixture of gases and fine particles from burning trees and other plant materials, it can irritate eyes and cause damage to respiratory systems causing shortness of breath, chest pain, headaches, asthma exacerbations, coughing, and death. For those with heart disease, rapid heartbeat and fatigue may be experienced more readily under smoky conditions.

Included in the destruction by fires are the leaf and other litter on the forest floor. This exposes the soil to erosive forces, allowing rainstorms to wear away the naked soil and wash silt and debris downhill, which will clog the streams and damage fertile farmlands in the valleys. Once the litter and humus (spongy layer of decaying matter) is destroyed, water flows more swiftly to the valleys and increases flood danger.

Other consequences of wildfires are the death of and loss of habitat for the forest's wildlife. The heaviest wildlife lost is felt by game birds since they have ground nesting habits. Fish life also suffers because of the removal of stream shade and the loss of insect and plant food is destroyed by silt and lye from wood ashes washed down from burned hillsides.

Wildland fires are usually signaled by dense smoke that fills the area for miles around. The average forest fire kills most trees up to 3-4 inches in diameter, in the area burned. These trees represent approximately 20 years of growth. In the case of up-slope burning, under severe conditions, almost every tree is killed regardless of size or type. When the trees are burned and everything is killed, then the forest is slow to reestablish itself, because of the loss of these young seedlings, saplings, pole, and timber trees.

Louisville Metro Wildfire History

According to wildfire data provided by the Kentucky Division of Forestry there have been six identified wildfires in Louisville Metro from 2006 to 2015. These were small scale events on the following dates:

February 27, 2006
March, 12, 2007
November 22, 2010
April 10, 2011
April 3, 2013
March 14, 2014

Local data shows that on October 12, 2010, a small campfire in the Pleasure Ridge Park area ignited a fire with 20- foot high flames and burned across three acres. It happened off of St. Andrews Church Road, just across from Doss High School and very close to an apartment complex.

4.14.3. Assessing Vulnerability: Wildfire

Wildfire Vulnerability Score = Exposure Score + Risk Score

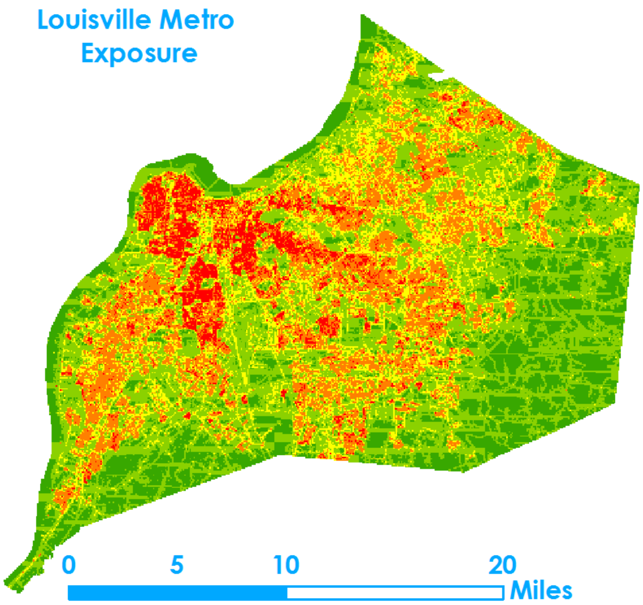
Risk Score = Geographic Extent Score x Occurrence Score

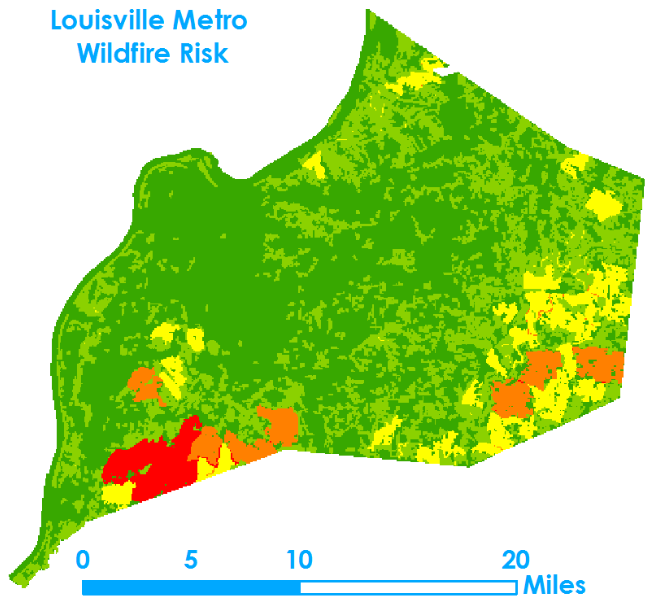
Geographic Extent Score = percentage of the grid cell in a 3-acre area of tree/vegetation cover. (LOJIC tree cover layer). The 3-acre or greater rule was discussed with Metro's local fire personnel and believed to be the best way to identify at risk areas. Percentages were then scored on 0-1 scale for Geographic Extent score

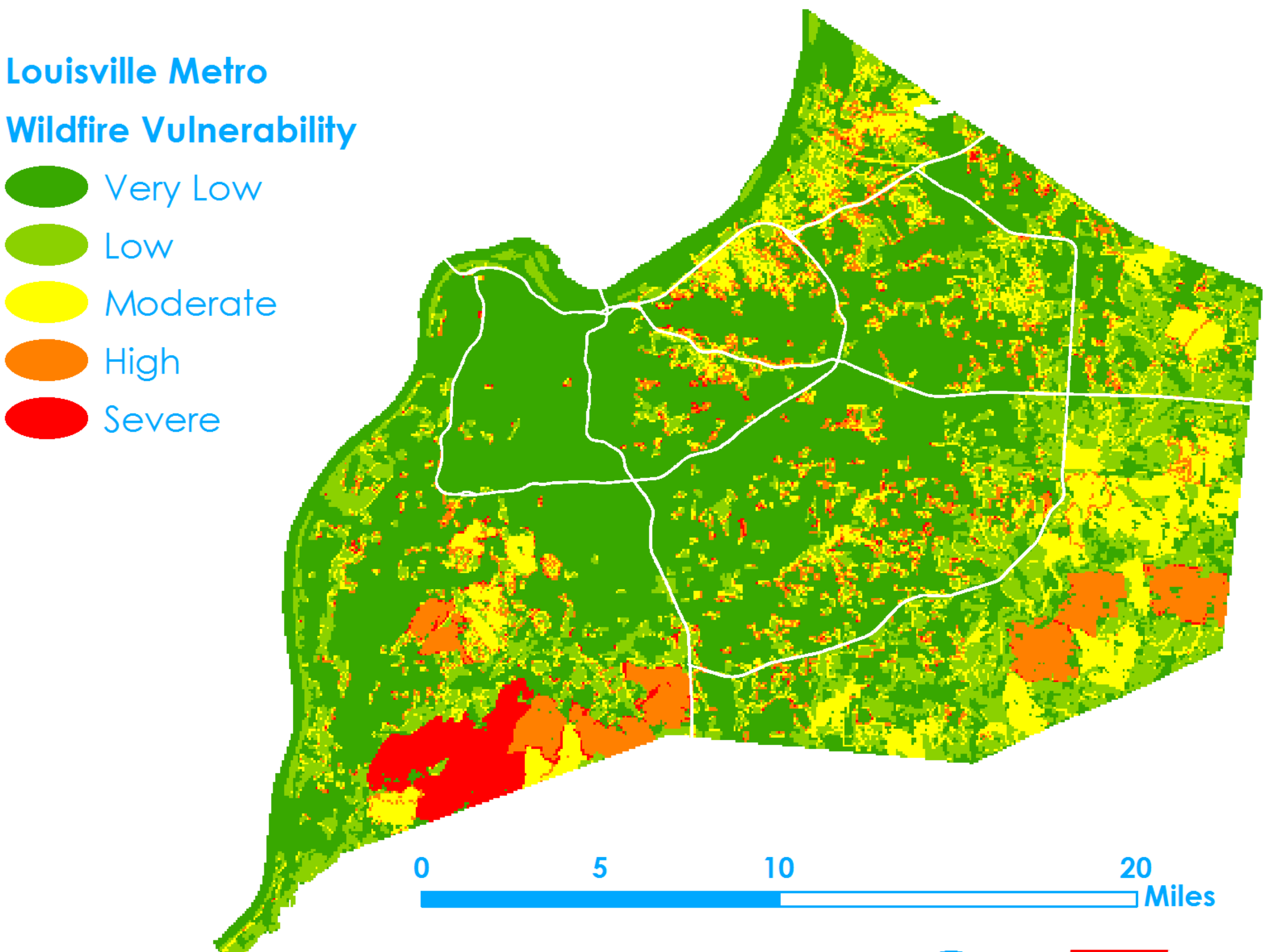
Occurrence Score = number of wildfires in each grid cell, counts were scored on 0-1 scale

The Wildfire Risk Score and the Exposure score were added together and a new 0-1 score was calculated to give the final Wildfire Vulnerability Score (Figure 16).

Figure 16. Wildfire Hazard Vulnerability Map







Sources: LOJIC, Louisville MSD, US Census Bureau, Louisville EMA, Louisville Water Company, LG&E/KU, National Weather Service, Kentucky Geological Survey, Jefferson County PVA, Kentucky Division of Forestry

4.15. Dam/Levee Failure

4.15.1. Identify: Dam/Levee Failure

Kentucky statute KRS 150.100 defines a dam as any artificial barrier including appurtenant works that do, or can, impound or divert water and:

- Is 25 feet or more high from the natural bed of the stream or watercourse at the downstream toe of the barrier, as determined by the Natural Resources and Environmental Protection Cabinet;
- Has or will have an impounding capacity of 50 acre feet or more at the maximum water storage elevation.

There are about 80,000 dams in the U. S., the majority of which are privately owned. Other owners are state and local authorities, public utilities, and federal agencies. The benefits of dams are numerous; they provide water for drinking, navigation, and agricultural irrigation. Dams also provide hydroelectric power and create lakes for fishing and recreation. Most important; dams save lives by preventing/reducing floods.

If dams have many benefits, they can also pose a risk to communities if not designed, operated, and maintained properly. In the event of a dam failure, the energy of the water stored behind even a small dam is capable of causing loss of life and great property damage if there are people downstream of the dam. Historically, dams that failed had some deficiency, as characterized above, which caused the failure. These dams are typically termed "unsafe”. The National Dam Safety Program is dedicated to protecting the lives of American citizens and property from the risks associated with the development, operation, and maintenance of America's dams.

Dam and Levee Failure Flooding are potentially the worst flood events. A dam failure is usually the result of neglect, poor design, or structural damage caused by a major event such as an earthquake. When a dam fails, an excess amount of water is suddenly let loose downstream, destroying anything in its path. Many dams and levees are built for flood protection. They usually are engineered to withstand a flood with a computed risk of occurrence. For example, a dam or levee may be designed to contain a flood at a location on a stream that has a certain probability of occurring in any one year. If a larger flood occurs, then that structure may be overtopped. If during the overtopping the dam or levee fails or is washed out, the water behind it is released and becomes a flash flood. Failed dams or levees can create floods that are catastrophic to life and property because of the tremendous energy of the released water.
Dam Types

Manmade dams may be classified by:

- The type of materials used
- The methods used in construction
- The slope or cross-section of the dam
- The way the dam resists water pressure forces
- The means for controlling seepage
- The purpose of the dam

Materials used for dams may include earth, rock, tailings from mining or milling, concrete, masonry, steel, timber, and/or miscellaneous materials (such as plastic or rubber).

- Embankment dams are the most common type of dam in use today. Materials include natural soil or rock, or waste materials obtained from mining or milling operations. An embankment dam is termed an "earth-fill" or "rock-fill" dam depending on whether it is comprised of compacted earth or of dumped rock. The ability of an embankment dam to resist the reservoir water pressure is primarily a result of the mass weight, type and strength of the materials from which the dam is made.
- Concrete dams may be categorized as gravity or arch dams according to the design used to resist the stress of reservoir water pressure. Concrete gravity dams use the mass weight of concrete and friction to resist reservoir water pressure. A buttress dam is a specific type of gravity dam in which the large mass of concrete is reduced, and the forces are diverted to the dam foundation through vertical or sloping buttresses.
- Concrete arch dams are typically thin in cross-section. The reservoir water forces acting on an arch dam are carried laterally into the abutments. The shape of the arch may resemble a segment of a circle or an ellipse, and the arch may be curved in the vertical plane as well. Such dams are usually constructed of a series of thin vertical layers that are keyed together; barriers to stop water from flowing are provided between layers.
- Coal impoundments are defined by the Mining Safety and Health Administration (MSHA) as any structure associated with coal mining operations built to impound water and, are either at least 20 feet high, or capable of impounding at least 20 acre feet of water. Coal impoundments store coal slurry (wastewater and impurities that result from coal washing and processing). A bulkhead or embankment is made of coarse coal refuse and acts as a dam. Behind it lies a pond of coal slurry. Sediment settles out of this turbid mixture, filling the pond, while wastewater is recycled back into the coal washing process. The sizes of the ponds and bulkheads vary, but pond basins are often hundreds of feet deep and hold millions of gallons of slurry. As of this year, coal impoundment failures have resulted in property damage, environmental contamination and, in one case, loss of life.

Likelihood of Occurrence: Signs of Potential Dam Failure

- Seepage. The appearance of seepage on the downstream slope, abutments, or downstream area is cause for concern. If the water is muddy and is coming from a well-defined hole, material is probably being eroded from inside the embankment and a potentially dangerous situation can develop.
- Erosion. Erosion on the dam and spillway is one of the most evident signs of danger. The size of erosion channels and gullies can increase greatly with slight amounts of rainfall.
- Cracks. Cracks are of two types: transverse and longitudinal. Transverse cracks appear perpendicular to the axis of the dam and indicate settlement of the dam. Longitudinal cracks run parallel to the axis of the dam and may be the signal for a slide, or slump, on either face of the dam.
- Slides and Slumps. A massive slide can mean catastrophic failure of the dam. Slides occur for many reasons and an occurrence can mean a major reconstruction effort.
- Subsidence. Subsidence is the vertical movement of the foundation materials due to failure of consolidation. Rate of subsidence may be so slow that it can go unnoticed without proper inspection. Foundation settlement is the result of placing the dam and reservoir on an area lacking suitable strength, or over collapsed caves or mines. Structural. Conduit separations or ruptures can result in water leaking into the embankment and subsequent weakening of the dam. Pipe collapse can result in hydraulic failures due to diminished capacity.
- Vegetation. A prominent danger signal is the appearance of "wet environment" types of vegetation such as cattails, reeds, mosses and other wet area vegetation, which can be a sign of seepage.

- Boils. Boils indicate seepage water exiting under some pressure and typically occur in areas downstream of the dam.
- Animal Burrows. Animal burrows are a potential danger since such activity can undermine the structural integrity of the dam.
- Debris. Debris on dams and spillways can reduce the function of spillways, damage structures and valves, and destroy vegetative cover.

Dams are classified based on the evaluation of damage possible downstream. The FEMA guide to dam classifications uses the following system:

Classification	Description
Class A (Low)	No loss of human life is expected and damage will only occur to the dam owner's property
Class B (Moderate/Significant)	Loss of human life is not probable, but economic loss, environmental damage, and/or disruption of lifeline facilities can be expected
Class C (High)	Loss of one or more human life is expected

4.15.2. Profile: Dam / Levee Failure

Profile Risk Table	
Period of occurrence:	At any time
Number of events:	0
Probability of events:	N/A
Past Damages	N/A
Warning time:	Minimal, depends on frequency of inspection.
Potential impact:	Impacts human life and public safety. Economic loss, environmental damage, and/or disruption of lifeline facilities. High Hazard-classified dam failure would cause loss of life, serious damage to homes, industrial or commercial buildings, important utilities, main highways Moderate Hazard-failure would cause significant damage to property, homes, highways, utilities but no loss of life. Low Hazard-failure would cause loss of dam, little or no damage to other structures or loss of life.
Potential of injury or death:	Dam/Levee has a low potential for injury or death in Louisville.
Possible Extent:	A dam failure at one of the identified High Hazard Dams

Since 1948, anyone in Kentucky proposing to construct a dam has been required to submit a plan to the state for review in order to obtain a permit. In 1966, Kentucky adopted a set of guidelines for evaluating dams. In 1974, the permit system was revised to include regular state inspection of dams. KRS 150.295 directs the Secretary of the Natural Resources and Environmental Protection Cabinet to inspect dams and reservoirs on a regular schedule.

The Dam Safety and Security Act of 2002 (Public Law 107-310): signed into law on December 2, 2002, addresses safety and security for dams through the coordination by FEMA of federal programs and initiatives for dams and the transfer of federal best practices in dam security to the states. The Act of 2002 includes resources for the development and maintenance of a national dam safety information network and the development of a strategic plan that establishes goals, priorities, and target dates to improve the safety and security of dams in the U.S.

Historical Impact

Kentucky has approximately 1,000 dams, with almost 200 dams being identified by FEMA as High Hazard – or Class C – dams. Since 1973, there have been 11 dam malfunctions reported to the National Performance Dam Program, seven of those being complete dam failures. There have been no malfunctions or failures in Louisville Metro.

Coal impoundments also pose a severe threat to humans and the environment in the event of failure. According to the MSHA, of the 713 impoundments nationwide, 121 are found in Kentucky and 60 of those are high risk impoundments in terms of retaining failure. (2010 KY Hazard Mitigation Plan).

Types of Dam Failures

- Hydraulic Failure. Hydraulic failures result from the uncontrolled flow of water over the dam, around the dam and adjacent to the dam, and the erosive action of water on the dam and its foundation. Earth dams are particularly vulnerable to hydraulic failure since earth erodes at relatively small velocities.

- Seepage Failure. All dams exhibit some seepage that must be controlled in velocity and amount. Seepage occurs both through the dam and the foundation. If uncontrolled, seepage can erode material from the foundation of an earth dam to form a conduit through which water can pass. This passing of water often leads to a complete failure of the structure, known as piping.
- Structural Failure. Structural failures involve the rupture of the dam and/or its foundation. This is particularly a hazard for large dams and for dams built of low strength materials such as silts, slag, fly ash, etc. Dam failures generally result from a complex interrelationship of several failure modes. Uncontrolled seepage may weaken the soils and lead to a structural failure. Structural failure may shorten the seepage path and lead to a piping failure. Surface erosion may lead to structural or piping failures.

Potential Damage by Dam Failure

Dam-and Levee-Failure Flooding are potentially the worst flood events. A dam failure is usually the result of neglect, poor design, or structural damage caused by a major event such as an earthquake. When a dam fails, an excess amount of water is suddenly let loose downstream, destroying anything in its path. Many dams and levees are built for flood protection and usually are engineered to withstand a flood with a computed risk of occurrence. For example, a dam or levee may be designed to contain a flood at a location on a stream that has a certain probability of occurring in any one year. If a larger flood occurs, then that structure may be overtopped. If during the overtopping the dam or levee fails or is washed out, the water behind it is released and becomes a flash flood. Failed dams or levees can create floods that are catastrophic to life and property because of the tremendous energy of the released water.

Louisville Metro Dam/Levee Inventory

Following is an inventory of Louisville Metro dams maintained by the U.S. Army Corps of Engineers and the Kentucky Cabinet for Natural Resources and Environmental Protection, Division of Water. The nine Class C dams are at the highest risk and are required to have an emergency action plan, which is maintained by the dam owner.

The list of Louisville Metro's 40 dams according to the Kentucky Division of Water (KDOW) is as follows:

	Name of Dam	Hazard Cass	Owner Type	Location	Height	Area
1.	Tom Wallace Lake Dam	(Class C) High	MUN	Valley Station	31	2.5
2.	Pine Hill Lake No 1	(Class C) High	PRI	Louisville West	27	2.8
3.	Windsor Forest Dam	(Class C) High	PRI	Louisville West	29	4
4.	Mitchell Hill Lake Dam	(Class C) High	PRI	Valley Station	20	1.9
5.	LG&E Waste Water Dam	(Class C) High	PRI	Lanesville	12	40
6.	S Fork Beargrass Creek Dry Bed Dam	(Class C) High	MUN	Jeffersontown		13.9
7.	Roberson Run (Dry Impoundment)	(Class C) High	MUN	Louisville East	17	0
8.	Whipps Mill Rd Dry Dam	(Class C) High	MUN	Anchorage	21	
9.	Norton Commons Dam	(Class C) High	PRIV	Anchorage	16	2.4
10.	Waterstone Park Dam	(Class B) Moderate	PRIV	Louisville East	32	
11.	Silver Crystal Dam	(Class B) Moderate	PRIV	Brooks	15	10.2
12.	Lake McNeely Dam	(Class B) Moderate	DOFW	Brooks	32	45
13.	Long Run Park Lake Dam	(Class B) Moderate	MUN	Crestwood	43	27
14.	Big Horn Lake Dam	(Class B) Moderate	PRI	Valley Station	28	3.7
15.	Waverly Park Dam	(Class B) Moderate	PRI	Louisville West	20	4.9
16.	Mirror Lake (Lower) Dam	(Class B) Moderate	PRI	Jeffersontown	28	3.7
17.	Joe Guy Hagan Dam	(Class B) Moderate	PRI	Jeffersontown	28	4.5
18.	LG&E Mill Creek Station Ash Dam A	(Class B) Moderate	PRI	Kosmosdale	77	56.91
19.	NTS Detention Dam Section 6b	(Class B) Moderate	PRI	Jeffersontown	21	4.2
20.	Polo Fields	(Class B) Moderate	PRIV	Crestwood	27	13.3
21.	AS Properties Dam No 2	(Class B) Moderate	PRIV	Jeffersontown	24	2
22.	Vulcan Quarry Dam	(Class B) Moderate	MUN	Brooks	16	
23.	Riggs Lake Dam	(Class A) Low	PRI	Jeffersontown	18	8.9
24.	Fern Creek Sportsman Club Dam	(Class A) Low	PRI	Waterford	25	2.8
25.	Dreamland Dam	(Class A) Low	PRI	Louisville West	13	5
26.	Woodhaven Country Club Dam	(Class A) Low	PRI	Louisville East	18	4.6
27.	Lowry Dam	(Class A) Low	PRI	Jeffersontown	35	2
28.	Wildwood Country Club Dam	(Class A) Low	PRI	Jeffersontown	18	4.6
29.	Sampson Dam	(Class A) Low	PRI	Fisherville	40	7.9
30.	Willow Dam	(Class A) Low	PRI	Anchorage	33	7.4
31.	Putneys Pond	(Class A) Low	PRI	Anchorage	15	7.3
32.	Logan Lake Dam	(Class A) Low	PRI	Fisherville	36	5.8
33.	Bill Mcmahan Lake Dam	(Class A) Low	PRI	Jeffersontown	35	
34.	Twin Lakes Lower Dam	(Class A) Low	PRI	Fisherville		
35.	Du Pont Fly Ash	(Class A) Low	PRI	Louisville West	18	20
36.	Glenmary Dam	(Class A) Low	PRI	Mount Washington	25	4.21
37.	Lake Forest Golf Course No 2	(Class A) Low	PRI	Crestwood	21	6.5
38.	Lake Forest Golf Course No 1	(Class A) Low	PRIV	Crestwood	23	5
39.	Springhurst Lake Dam	(Class A) Low	PRIV	Anchorage	18	5.7
40.	Gault Eastpoint Llc Dam	(Class A) Low	PRIV	Anchorage	20	5.4

4.15.3. Assessing Vulnerability: Dam/Levee Failure

Dam/Levee Failure Vulnerability Score = Exposure Score + Risk Score

Risk Score = Geographic Extent Score + Occurrence Score

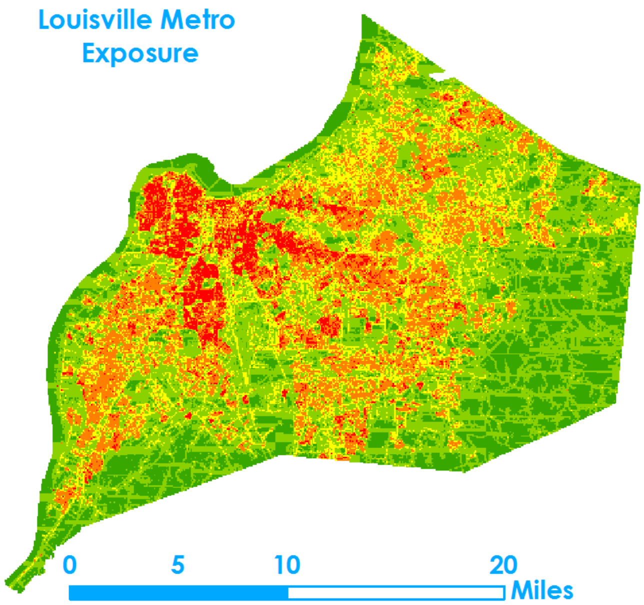
Geographic Extent = % of grid cell in dam inundation and levee protection areas. Geographic Extent was calculated for each grid cell and then scored on 0-1 scale

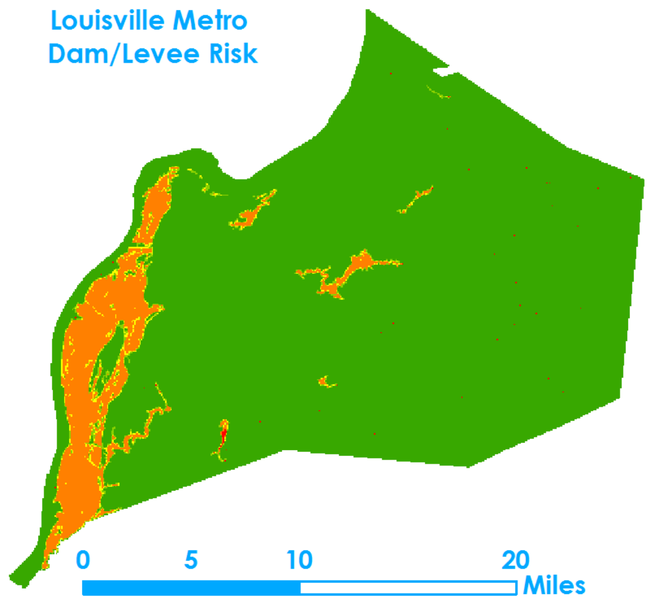
Occurrence Score = the number of dams in each grid cell. Dams were counted in each grid cell and the total was converted to a 0-1 score for each cell.

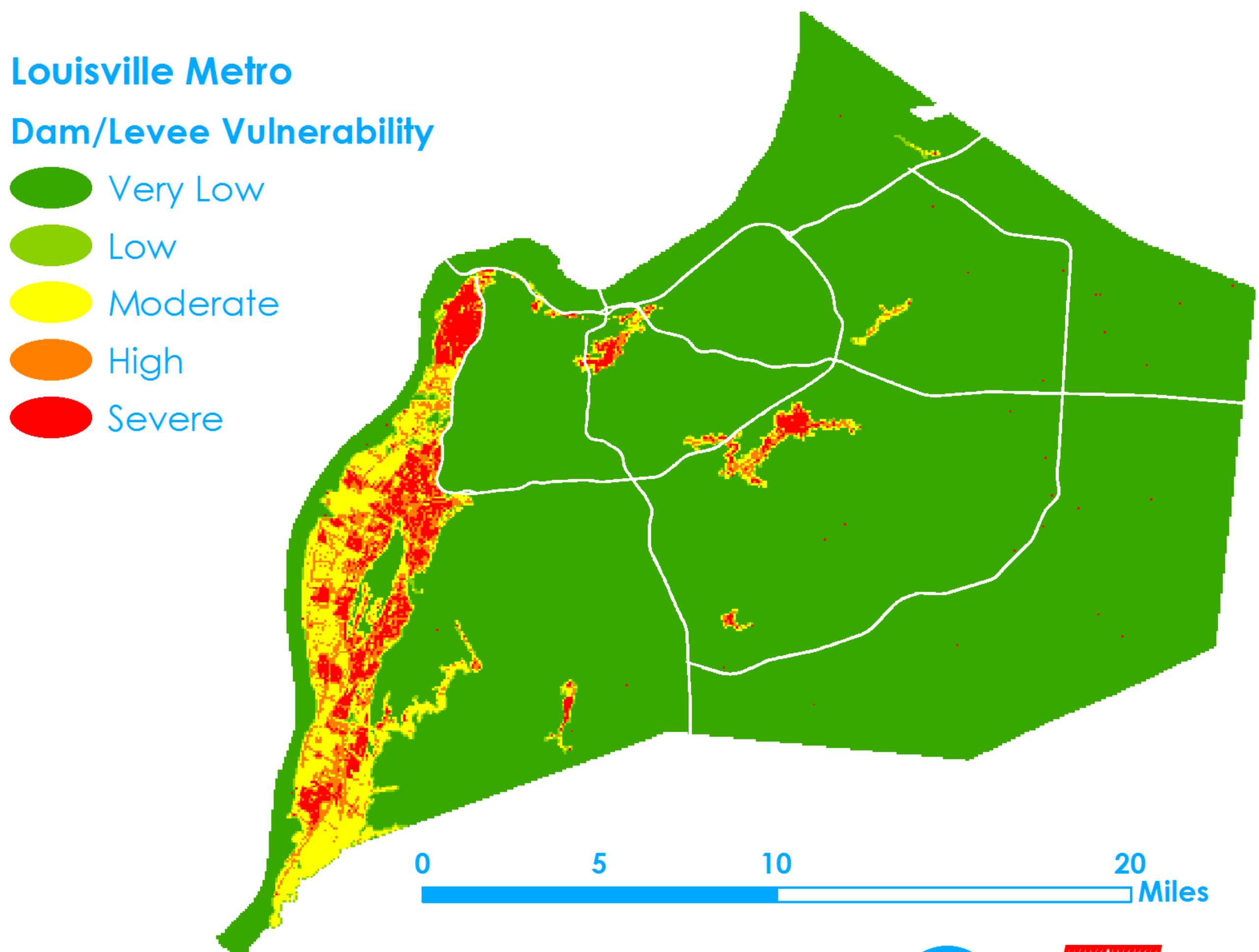
The Geographic Extent Score and the Occurrence Score were added together and the new total was converted to a 0-1 score resulting in the Dam/Levee Risk Score.

The Dam/Levee Risk Score and the Exposure score were added together and a new 0-1 score was calculated to give the final Dam/Levee Vulnerability Score (Figure 17).

Figure 17. Dam/Levee Failure Hazard Vulnerability Map







Sources: LOJIC, Louisville MSD, US Census Bureau, Louisville EMA, Louisville Water Company, LG&E/KU, National Weather Service, Kentucky Geological Survey, Jefferson County PVA

4.15.4. Assessing Vulnerability: Identifying Structures and Estimating Potential Losses: Dam/Levee Failure

In order to determine structures that are vulnerable and estimated to be damaged during a Dam/Levee Failure the project staff used the Hazard Boundary Overlay methodology. The Hazard Boundary used as the overlay was the Levee inundation map that was created during the update of the DFIRMs for Louisville Metro. This inundation map displays areas that would be flooded if the Levee was not in place, thus was used to showcase risk in this model.

Table 10 describes the total number of structures identified within the hazard boundary and the replacement cost of those structures. This model estimates complete damage of each structure located within the Hazard Boundary.

Table 10. Potential Losses from Dam/Levee Failure

Type	Structures
Agricultural	74
Industrial	1,837
Commercial	4,354
Residential	45,932
Other	1,482
Total Structures	**53,679**
Estimated Loss	**$2,674,538,840**

4.16. Flood

4.16.1. Identify: Flood

A flood is a natural event for rivers and streams and is caused in a variety of ways. Floods can be slow, or fast rising, but generally develop over a period of days. Winter or spring rains, coupled with melting snows, can fill river basins too quickly. Torrential rains from decaying hurricanes or other tropical systems can also produce flooding. The excess water from snowmelt, rainfall, or storm surge accumulates and overflows onto the banks and adjacent floodplains.

What is a Flood?

A flood is a general and temporary condition where two or more acres of normally dry land or two or more properties are inundated by water or mudflow. Many conditions can result in a flood: hurricanes, overtopped levees, outdated or clogged drainage systems and rapid accumulation of rainfall.

Source: FEMA

Floods are generally the result of excessive precipitation, and can be classified under two categories: flash floods, the product of heavy localized precipitation in a short time period over a given location; and general floods, caused by precipitation over a longer time period and over a given river basin.

In Kentucky, the severity of a flooding event is determined by a combination of stream and river basin topography and physiography, precipitation and weather patterns, recent soil moisture conditions and the degree of vegetative clearing. Flood currents also possess tremendous destructive power as lateral forces can demolish buildings and erosion can undermine bridge foundations and footings, leading to the collapse of structures.

Flash flooding events usually occur within minutes or hours of heavy amounts of rainfall, from a dam or levee failure, or from a sudden release of water held.

General floods are usually longer-term events and may last for several days. The primary types of general flooding include riverine flooding and urban flooding.

Periodic flooding of lands adjacent to rivers, and streams is a natural and inevitable occurrence that can be expected to take place based upon established recurrence intervals. The recurrence interval of a flood is defined as the average time interval, in years, expected between a flood event of a particular magnitude and an equal or larger flood. Flood magnitude increases with increasing recurrence interval. A "floodplain" is the lowland area adjacent to a river, lake, or ocean.

Floodplains are designated by the frequency of the flood that is large enough to cover them. One way of expressing the flood frequency is the chance of occurrence in a given year, which is the percentage of the probability of flooding each year. For example, the 100-year flood has a 1% chance of occurring in any given year.

Types

Floods are the result of a multitude of naturally occurring and human-induced factors, but they all can be defined as the accumulation of too much water in too little time in a specific area. Types of floods include regional floods, river or riverine floods, flash floods, urban floods, ice-jam floods, storm-surge floods, and debris, landslide, and mudflow floods. For information on dam- and levee-failure floods, see Dam Failure in this section of the Plan. For information on landslides, see Landslide in this section of the Plan.

- *Regional Flooding* can occur seasonally when winter or spring rains coupled with melting snow fill river basins with too much water too quickly. The ground may be frozen, reducing infiltration into the soil and thereby increasing runoff. Extended wet periods during any part of the year can create saturated soil conditions, after which any additional rain runs off into streams and rivers, until river capacities are exceeded. Regional floods are many times associated with slow-moving, low-pressure or frontal storm systems including decaying hurricanes or tropical storms.
- *River or Riverine Flooding* is a high flow or overflow of water from a river or similar body of water, occurring over a period of time too long to be considered a flash flood. Riverine flooding is a function of excessive precipitation levels and water runoff volumes within the watershed of a stream or river.
- *Flash Floods* are quick-rising floods that usually occur as the result of heavy rains over a short period of time, often only several hours or even less. Several factors can contribute to flash flooding. Among these are rainfall intensity, rainfall duration, surface conditions, and topography and slope of the receiving basin. Flash floods can occur within several minutes to several hours and with little warning. They can be deadly because they produce rapid rises in water levels and have devastating flow velocities. Most flash flooding is caused by slow-moving thunderstorms in a local area or by heavy rains associated with hurricanes and tropical storms. Although flash flooding occurs often along mountain streams, it is also common in urbanized areas where much of the ground is covered by impervious surfaces.
- *Urban Flooding* is possible when land is converted from fields or woodlands to roads and parking lots; thus, losing its ability to absorb rainfall. Urbanization of a watershed changes the hydrologic systems of the basin. Heavy rainfall collects and flows faster on impervious concrete and asphalt surfaces. The water moves from the clouds, to the ground, and into streams at a much faster rate in urban areas. Adding these elements to the hydrological systems can result in floodwaters that rise very rapidly and peak with violent force. During periods of urban flooding, streets can become swift moving rivers and basements can fill with water. Storm drains often back up with vegetative debris causing additional, localized flooding.
- *Ice-Jam Flooding* occurs on rivers that are totally or partially frozen. A rise in stream stage will break up a totally frozen river and create ice flows that can pile up on channel obstructions such as shallow riffles, log jams, or bridge piers. The jammed ice creates a dam across the channel over which the water and ice mixture continues to flow, allowing for more jamming to occur. Backwater upstream from the ice dam can rise rapidly and overflow the channel banks. Flooding moves downstream when the ice dam fails, and the water stored behind the dam is released. At this time the flood takes on the characteristics of a flash flood, with the added danger of ice flows that, when driven by the energy of the flood-wave, can inflict serious damage on structures. An added danger of being caught in an ice-jam flood is hypothermia, which can quickly kill.
- *Debris, Landslide, and Mudflow Flooding* is created by the accumulation of debris, mud, rocks, and/or logs in a channel, forming a temporary dam. Flooding occurs upstream as water becomes stored behind the temporary dam and then becomes a flash flood when

the dam is breached and rapidly washes away. Landslides can create large waves on lakes or embayments and can be deadly.

Urban areas are susceptible to flash floods because a high percentage of the surface area is composed of impervious streets, roofs, and parking lots where runoff occurs very rapidly. Floodwaters accelerated by steep stream slopes can cause the flood-wave to move downstream too fast to allow escape, resulting in many deaths.

Factors determining the severity of floods include:

- Rainfall intensity and duration
  - A large amount of rain over a short time can result in flash flooding
  - Small amounts may cause flooding where the soil is saturated
  - Small amounts may cause flooding if concentrated in an area of impermeable surfaces
- Topography and ground cover
- Water runoff is greater in areas with steep slopes and little vegetation

Flood Facts for the U. S.

- On average, there are about 145 deaths each year due to flooding. 80% of flood deaths occur in vehicles, and most happen when drivers try to navigate through floodwaters.
- Only six inches of rapidly moving floodwater can knock a person down and a mere two feet of water can float a vehicle.
- One-third of flooded roads and bridges are so damaged by water that any vehicle trying to cross stands only a 50% chance of making it to the other side.
- About one-third of insurance claims for flood damages are for properties located outside identified flood hazard areas.

Definitions

Base Flood Elevation (BFE)
The elevation shown on the Flood Insurance Rate Map (FIRM) for Zones AE, AH, A1-A30, AR, AR/A, AR/AE, AR/A1-A30, AR/AH, AR/AO, V1-V30, and VE that indicates the water surface elevation resulting from a flood that has a 1% chance of equaling or exceeding that level in any given year.

Community Rating System (CRS)
A program developed by the FEMA Mitigation Division to provide incentives for those communities in the National Flood Insurance Program that have gone beyond the minimum floodplain management requirements to develop extra measures to provide protection from flooding.

Elevation Certificate
A certificate that verifies the elevation data of a structure on a given property relative to the ground level. The Elevation Certificate is used by local communities and builders to ensure compliance with local floodplain management ordinances and is also used by insurance agents and companies in the rating of flood insurance policies.

Floodplain
Any land area susceptible to being inundated by floodwaters from any source.

National Flood Insurance Program (NFIP)
A federal program enabling property owners in participating communities to purchase insurance protection against losses from flooding. This insurance is designed to provide an insurance alternative to disaster assistance to meet the escalating costs of repairing damage to buildings and their contents caused by floods.

Non-Special Flood Hazard Area (NSFHA)
An area in a moderate- to low-risk flood zone (Zones B, C, X) that is not in any immediate danger from flooding caused by overflowing rivers or hard rains. However, it's important to note that structures within a NSFHA are still at risk.

Special Flood Hazard Area (SFHA)
A FEMA-identified high-risk flood area where flood insurance is mandatory for properties. An area having special flood, mudflow, or flood-related erosion hazards, and shown on a Flood Hazard Boundary Map or a Flood Insurance Rate Map as Zone A, AO, A1-A30, AE, A99, AH, AR, AR/A, AR/AE, AR/AH, AR/AO, AR/A1-A30, V1-V30, VE, or V.

Regulatory Floodway
The channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height.

Freeboard
An additional amount of height above the Base Flood Elevation (BFE) used as a factor of safety (e.g., 2 feet above the Base Flood) in determining the level at which a building's lowest floor must be elevated or floodproofed to be in accordance with state or community floodplain management regulations.

1% Annual Chance or Base Flood
The flood having a one percent chance of being equaled or exceeded in any given year. This is the regulatory standard also referred to as the "100-year flood." The base flood is the national standard used by the National Flood Insurance Program (NFIP) and all Federal agencies for the purposes of requiring the purchase of flood insurance and regulating new development. Base Flood Elevations (BFEs) are typically shown on Flood Insurance Rate Maps (FIRMs).

Regulatory floodplain
For purposes of the Community Rating System, the regulatory floodplain is the flood-prone land area that is subject to a community's floodplain development or floodplain management regulations. The regulatory floodplain includes, at a minimum, the Special Flood Hazard Area (SFHA) (see definition), but may also incorporate other areas outside the SFHA that are also subject to a community's floodplain development or floodplain management regulations.

4.16.2. Profile: Flood

Profile Risk Table	
Period of occurrence:	Ohio River: December through May Flash Floods: anytime, but primarily during Summer rains
Number of events:	127
Probability of events:	6.35
Past Damages	$251,915,000
Warning time:	River flooding – 3 –5 days Flash flooding – minutes to hours Out-of-bank flooding – several hours/days
Potential impact:	Impacts human life, health, and public safety. Utility damage and outages, infrastructure damage (transportation and communication systems), structural damage, fire, damaged or destroyed critical facilities, and hazardous material releases. Can lead to economic losses such as unemployment, decreased land values, and Agro-business losses. Floodwaters are a public safety issue due to contaminants and pollutants.
Potential of injury or death:	Dam/Levee has a moderate potential for injury or death in Louisville, mostly from flash flooding.
Possible Extent:	1937 – Over 60% of the city was inundated, 190 flood-related deaths

Flooding is the most significant natural hazard in Kentucky. Major flooding occurs within the state almost every year and it is not unusual for several floods to occur in a single year. Flooding is Kentucky's most costly natural disaster. The economic, social, and physical damage resulting from floods can be severe.

Because Flood is the most severe hazard in Louisville Metro, the following risk assessment is divided into 11 watershed assessments following the Community Rating System (CRS) criterion. Similar to the other sections, a general countywide overview of the hazard provides a general overview. A detailed watershed breakdown follows describing each watershed's risk assessment.

History of Flooding in Louisville

The following table shows the flood-related Presidentially Declared Disasters for Louisville Metro.

In general, the two most common types of flooding that occur in Louisville Metro area are flash floods and Ohio River flooding.

Newspaper accounts and historical records show that during the 19th century large Ohio River floods occurred in 1832, 1847, 1859, 1867, 1883, and 1884. Major floods in the 20th century have occurred in 1907, 1913, 1933, 1937, 1945, 1948, 1964, and 1997. Thus, it can be seen that serious flooding has occurred in the Louisville area on the average of about once every 10 years.

The normal elevation of the upper pool of the Ohio River is approximately 420' above mean sea level (NGVD). Overbank flooding occurs at approximate elevation 430.5', and the base flood elevation (BFE) varies between 443' and 455'.

The major flash flooding problem in Louisville/Jefferson County is related to out-of-bank flash flooding. Out-of-bank flooding is defined as flooding that occurs when the natural embankments of a watercourse are breached. Additionally, ponding also may result in certain areas, at their lowest elevations. The community is also vulnerable to other flooding situations due to street runoff, erosion, and sewer and drainage problems.

The main flood season for the Ohio River is between the months of January and May. All of the highest floods on record have resulted from general heavy rains throughout the Ohio River Basin. In both summer and fall, intense local thunderstorms also can contribute significantly to local flash flooding and interior drainage problems.

The average duration of Ohio River floods of record in Louisville Metro is about 12 days. However, the sustained flood duration in 1937 was 23 days, in 1945 it was 18 days, and in 1964 and 1997 it was 14 days. The rate of rise at levels above flood stage varies in relation to rainfall and runoff rates for specific storms. Typical rates of rise for the Ohio River, at levels above flood stage, range from 2.5 to 5 inches per hour with the record rate of rise being 4.7 feet in 12 hours and 8.4 feet in 24 hours in 1964.

Following are examples of the larger local flood events.

January 1913
The New Year in 1913 brought extensive rains to Kentucky and surrounding states causing every major river and stream in Kentucky to flood. Kentucky's total average rainfall for January was 11.41 inches, three times the normal amount. The U.S. Weather Bureau described the lowland areas of the state as being "vast inland seas". The Monthly Weather Review for January of that year collected details of the damage in dollar amounts. For the Louisville district, it reported property damages from the flood at $200,000, a very large sum for 1913. Total crop losses in the Louisville district totaled $50,000.

January 1937
In January of 1937, rains began to fall throughout the Ohio River Valley; eventually triggering what is known today as the "Great Flood of 1937". Overall, total precipitation for January was four times its normal amount in the areas surrounding the river. In fact, there were only eight days in January when the Louisville station recorded no rain. These heavy rains, coupled with an already swollen river, caused a rapid rise in the river's level.

The morning of January 24 the entire Ohio River was above flood stage. In Louisville, the river rose 6.3 feet from January 21-22. As a result, the river reached nearly 30 feet above flood stage. Louisville, where light and water services had failed, was the hardest hit city along the Ohio River. On January 27, the river reached its crest at 460 feet above sea level or 40 feet above its normal level, which is well over a 100-year event. Almost 70 percent of the city was under water, and 175,000 people were forced to leave their homes. The U.S. Weather Bureau reported that total flood damage for the entire state of Kentucky was $250 million, an incredible sum in 1937. The number of flood-related deaths rose to 190. The flood completely disrupted the life of Louisville, inundating 60% of the city and 65 square miles.

March 1945
Although the Great Flood of 1937 gets most of the attention, and perhaps deservedly so, the flood that beset the Ohio River Valley eight years later was also extremely damaging. While 1937 is the flood of record at Louisville, 1945 is in second place (albeit a distant 2nd), with a peak

stage at Louisville of 74.4 feet. This stage is about eleven feet below the 1937 stage, and ties with the stage set during the devastating 1884 flood.

As is almost always the case with massive Ohio River floods, snow melt had very little impact. The deepest snow cover at Louisville between New Year's Day and the flood was only 3 inches on the 29th of January, and that melted away in a few days. The bulk of the heavy rain that caused the flood fell during a three week period leading up to the flood. Rainfall during that time was over 500% of normal in southern Indiana, and around 400% of normal along the length of the Ohio River

The rain came in four main waves, on February 20-21, February 25-26, March 1-2, and March 5-6. February 26 still stands as Louisville's 5th wettest February day on record (2.85"), and March 6 is the 10th wettest March day on record (2.66"). March 1945 is the 3rd wettest March on record, and February 1945 is actually only #19 on the list. However, instead of looking at calendar months, the period February 20 - March 8, 1945 is the second wettest such period on record at Louisville (1997 is #1).

March 1964
In 1964, the community experienced its third greatest flood of the 20th century. This flood approximated the 100-year base flood. Most of the flood damage occurred in the southwest section of the county with about 1,200 homes being flooded. Property damage was estimated at $3,600,000.

December 1978
A storm entered the southwest corner of Kentucky and moved northeast producing record-breaking rainfall totals for the entire area. On December 3, the Louisville Metro area received 2.77 inches of rain. Severe flooding occurred on the Licking, Kentucky, Salt, Green, and Ohio Rivers. Thirty-seven Kentucky counties received a federal disaster declaration due to five lives lost, and property damage at approximately $50 million. Flooding concentrated in Louisville and upstream with total damages of approximately $20 million.

February 1989
Precipitation was above normal in Kentucky in the months of December 1988 and January 1989, following an extreme drought during the summer and fall of 1988. By the end of January 1989, minor flooding had occurred on most rivers and streams in Kentucky, setting the stage for major flooding in February 1989. Between February 12-16 rain totals were 8 to 12 inches for an area stretching from Paducah to Lexington. During February, the Louisville Metro area received 9.02 inches of rain, one of the highest totals on record. The President issued a disaster declaration for 67 counties in Kentucky.

May 26 1996
Several roads across southern Jefferson County were closed due to high waters as 4 inches of rain fell between 11 pm EST May 25 and 11 am EST May 26. Area creeks were already backed up due to the near-flooded Ohio River. Fifty residents of a nursing home on Dixie Highway had to be relocated when a sump pump failure allowed the halls to be filled with water.

March 1997
Numerous strong thunderstorms along a stalled out warm front triggered a record 24-hour rainfall for Louisville Metro. On March 1, the Louisville Metro area received 7.22 inches of rain, the highest total on record for one-day. The combination of flooding and/or flash flooding from the record

rainfall resulted in an estimated 50,000 homes affected by flooding. Many of these homes had basements entirely flooded with water into the main floor. The Ohio River crested on March 7 in Louisville at about nearly 15' feet above flood stage.

Inland Ponding: The hardest hit areas were in the southwestern section of Louisville Metro along the Ohio River. Two other inland areas hit hard were in the Pond Creek watershed south of Louisville and along Floyds Fork in the east. More than 50,000 residences experienced some level of flooding. In addition, high water briefly closed Interstates 64 and 65, as well as scores of secondary roads. The flood pump station at the mouth of Pond Creek alone moved 2.6 billion gallons of water a day, draining the flood-ravaged neighborhoods of Okolona and Fairdale. During the first few days of the flood, MSD received more than 7,000 calls mostly about sewer backups and surface flooding. MSD estimated that as many as 25,000 customers may not have reported basement backups during the March 1997 flood.

Ohio River Flood: As floodwaters began receding in southern Louisville Metro, the flood stage of the river became a threat. A week after the rains, the Ohio River crested in Louisville 15.8 feet above flood stage. Flooding along the Ohio River continued for two weeks throughout Kentucky. The President declared over 87 of the 120 counties in Kentucky federal disaster areas eligible for federal aid statewide.

Damages: Damage was estimated at $65 million not including the river flooding on the Ohio River. The southwest floodwall closures passed their first test and protected many areas that flooded in 1964 and 1978. The Ford factory on Fern Valley Road had damage to up to 1,500 Explorers. 24-hour rainfall totals beginning around February 28 to March 1 ranged from around 6 inches along the Ohio River to 11.5 inches across the communities of Okolona and Fairdale in the southern part of the county. The previous record 24-hour total was 6.97 inches. An estimated 2,500 homes in numerous subdivisions in Okolona and Fairdale and across other parts of the county had to be evacuated with hundreds relocated in temporary shelters. Okolona and Fairdale lie in the Pond Creek floodplain, which was formerly swampland.

National Guard had to get many of these people out by boat or dump trucks. Thousands of cars were evacuated or stalled out due to the high waters. Numerous rescues were made with people trapped in cars and in houses. Bloated storm sewers popped off manhole covers that left cars quickly inundated in advancing high water. Several roads were closed around the Jefferson County Memorial Forest due to mudslides. A 16-year-old boy was killed near Jeffersontown as his van was swept off the road by the swollen Chenoweth Creek. Numerous roads including parts of Interstate 65 and 64 were closed through the morning of March 2. Because of all the damage, the County-Judge Executive declared the county a state of emergency.

In Kentucky, twenty-one people were killed and an estimated $250 to $500 million in damages where caused by the flooding. The damages incurred by the entire Ohio River flood exceeded $1 billion and over 67 deaths. Fortunately, floodwalls partially protected Louisville, preventing even more damage.

September 22-23, 2006
A slow-moving storm system brought torrential rains to the region on September 22 and 23, 2006, resulting in widespread flash flooding. Six people were killed in the Louisville NWS office's area of responsibility. It was the worst general flood since the March 1997 flood. It was the deadliest weather event in this area since seven people were killed in the flood of March 1-2, 1997, and the Super Outbreak of tornadoes on April 3, 1974 when 72 lives were lost.

The Bent Creek Apartments in the Buechel area were flooded. More than 100 residents had to be evacuated to an area shelter. Interstate 64 between Cannons Lane and Interstate 71 was closed. Water covered many roads in the vicinity of Veteran's Hospital in Louisville. Three feet of water covered 29th Street. Two to three feet of water covered Brownsboro Road about half a mile east of the Mellwood Avenue intersection. Water rescues were conducted in the Lake Forest area and in Jeffersontown. Old Henry Road was flooded and impassable. Property Damage estimates was $500K. Thirty-two flood insurance claims were filed for this event with a total of approximately $1.7M for both structure and contents damages.

April 3, 2008

A flood on the Ohio River covered local roads and caused damage to low-lying areas and structures. Several vehicles were submerged in the Louisville area, but no injuries or water rescues were reported. Numerous roads were closed due to flooding around the Louisville Metro area. Some of the closures included: a lane of Interstate 65 at the Woodbine exit, Third Street at Eastern Parkway, Breckinridge Lane at Six Mile Lane, Outer Loop at Preston Highway, and Outer Loop at New Cut Road. A frontal system and upper level low brought widespread heavy rains and flooding to central Kentucky. The event produced 40 flood insurance claims totaling $542,026 in structural and content damage.

August 4, 2009

Severe weather produced torrential rainfall in the Louisville Metro area with up to seven inches of rain falling in around two hours' time. This created massive flash flooding issues across the northwest and central part of Louisville Metro and caused millions of dollars in damage in Louisville.

The heavy rain and thunderstorms also produced some hail and cloud to ground lightning that caused several fires, including one four-alarm apartment complex fire on the east side of Louisville. See the map for a 3-hour synopsis of the rainfall at the end of this section.
Nearly 200 people were rescued by emergency workers from the tops of cars and houses. About 50 people were rescued by boat from a University of Louisville administrative office building. Two children were pulled from a swollen creek when neighbors saw them get swept away as they walked too close to the stream.

Water was reported up to several feet deep in parts of Louisville. Most of the downtown Louisville area received flooding with many commercial buildings in the immediate downtown area having damage. Many roads in the downtown area had several feet of water covering them, with residential buildings taking on water in basements. Numerous homes on the west side of town were also damaged.

Major flooding affected Churchill Downs and surrounding neighborhoods. Floodwaters poured into homes and engulfed Louisville's main public library downtown, several area hospitals, horse barns at Churchill Downs, and the University of Louisville campus. The entire basement of the Louisville Free Public Library was inundated with water causing damage to books, computers, vehicles, and other items. Thousands of books were destroyed at the Louisville downtown library, with a million dollars in damage.

The University of Louisville campus had several building damaged and flooded and water rescues had to be performed. Four of the U of L classroom buildings were closed for more than a month, resulting in a shuffling of numerous classroom locations.

Interstates 64, 65 and 264 were all closed for a period of time due to high water. Other water rescues were performed downtown as people became stranded in vehicles during rush hour traffic.

A Federal Disaster Declaration for Kentucky Severe Storms, Straight-line Winds, and Flooding was issued on August 14, 2009 (DR 1855). Louisville Metro citizens registered with FEMA for federal and Commonwealth disaster assistance following the August 4 severe weather and flooding. The registration period closed on October 13, 2009 with 12,288 registrations for Louisville Metro.
A summary of the Project Worksheets (PWs) submitted to KyEM for DR 1855 - Flooding is as follows:

Total Eligible Applicants – 33: Total Projects (PWs) 252

- Category A - $267,145.95 /PWs = 17
- Category B - $925,187.42 /PWs = 38
- Category C - $15,537.68 /PWs = 6
- Category D - $0 /PWs = 0
- Category E - $3,748,317.33 /PWs = 178
- Category F - $1,000,350.85 /PWs = 9
- Category G - $41,515.33 /PWs = 4

Total Project Amount - $599,805,456

April 23, 2011
Five to six inches of rain over a two day period caused a combination of flash flooding and Ohio River flooding. The storm caused at least 11 road closures due to flash flooding. River crested at 62.9 feet on April 27, 7.9 feet above flood stage. The river remained above flood stage into early May. Much of River Road under water and 3rd street ramp to 64 underwater downtown.

April 3, 2015
Heavy rains dropped between 2 and 8 inches of rain on Jefferson County on Friday, April 3, 2015. Over 200 road closures due to flash flooding caused Jefferson County Public Schools to close. A washed-out culvert left Highway 22 in eastern Jefferson County closed for several months. Louisville Metro Emergency Management Agency opened 3 different shelters for displaced residents. In addition to flash flooding, the storm caused widespread sewer back-ups

Jefferson County was designated for Individual assistance only. 666 applications, 326 for $864,517.29 for IA: 261 applicants for 626,771.75 for housing assistance and 151 applicants for 257,745.54 in other needs.

4.16.2.1. Repetitive Loss Areas

Louisville Metro has 5,194 flood insurance policies and 159 of these properties are Repetitive Loss Properties or Severe Repetitive Loss according to the current NFIP definitions. Louisville Metro has the highest number of repetitive loss properties in Kentucky.

As the floodplain administrator, MSD utilizes the Louisville Metro's community's official repetitive loss list to determine repetitive loss areas. The official repetitive loss list is provided through FEMA according to flood insurance claims.

Louisville Metro recognizes repetitive loss properties as prime targets for mitigation projects. Following are definitions for the three categories of repetitive loss.

Repetitive loss structure locations are a trigger to the community that other adjacent properties may be at-risk, and can provide the community an opportunity to designate a repetitive loss area that reflects the vulnerability of a street or neighborhood. A Repetitive Loss (RL) property is A property for which two or more National Flood Insurance Program losses of at least $1,000 each have been paid within any 10-year rolling period since 1978.

Historical claims data also helps a community identify floodprone areas. The repetitive loss and historic claims areas were identified as part of the Flood Risk Score so that appropriate enforcement, mitigation, and emergency measures are taken.

Severe repetitive loss property as defined in the Flood Insurance Reform Act of 2004, those 1–4 family properties that have had four or more claims of more than $5,000 or two to three claims that cumulatively exceed the building's value. For the purposes of the CRS, non-residential buildings that meet the same criteria as for 1–4 family properties are considered Severe Repetitive Loss properties.

For both (a) and (b) above, at least two of the referenced claims must have occurred within any ten-year period, and must be greater than 10 days apart.

Table 11 summarizes the total number and claims of Repetitive Loss, Severe Repetitive Loss, and Historical Claims across Louisville Metro. Table 12 summarizes Repetitive Loss and Severe Repetitive Loss Properties by Occupancy Type across Louisville Metro. Table 13 displays the total number of Repetitive Loss Properties, Severe Repetitive Loss, and Historical Claims by the eleven watersheds. This data can be used to identify areas at risk located outside of the floodplain.

Table 11. NFIP Claims

Type	Amount	Total Paid
Historical Claims	3196	$ 40,382,769
Repetitive Loss	424	$ 36,960,642
Severe Repetitive Loss	76	$ 12,536,411
Totals	**3696**	**$ 89,879,822**

Table 12. NFIP Claims by Type

Type	Single Family	Other Residential	Non-Residential	Assumed Condo	Other	Totals
Repetitive Loss	361	30	18	7	8	424
Severe Repetitive Loss	44	29	1	1	1	76
Totals	**405**	**59**	**19**	**8**	**9**	**500**

Table 13. NFIP Claims by Watershed

Watersheds	Repetitive Loss		Historical Claims		Severe Repetitive Loss	
	Claims	Total Paid	Claims	Total Paid	Claims	Total Paid
Cedar Creek	1	$ 128,633	18	$ 142,750	1	$ 128,633
City/Ohio River	96	$ 15,273,791	727	$ 15,307,615	33	$ 6,834,328
Floyds Fork	7	$ 661,223	51	$ 806,128	1	$ 167,253
Goose Creek	11	$ 1,176,472	70	$ 1,801,190	1	$ 450,115
Harrods Creek	0	$ -	43	$ 787,814	0	$ -
Middle Fork Beargrass Creek	9	$ 738,052	35	$ 287,481	1	$ 104,757
Mill Creek	19	$ 386,013	359	$ 2,239,250	0	$ -
Muddy Fork Beargrass Creek	5	$ 172,205	33	$ 353,325	0	$ -
Pennsylvania Run	0	$ -	5	$ -	0	$ -
Pond Creek	86	$ 4,691,776	1,072	$ 11,046,626	13	$ 1,258,559
South Fork Beargrass Creek	80	$ 4,220,613	224	$ 2,018,762	5	$ 473,981
TOTALS	**314**	**$ 27,448,778**	**2,637**	**$ 34,790,942**	**55**	**$ 9,417,627**

4.16.3. Assessing Vulnerability: Flood

Flood Vulnerability Score = Exposure Score + Risk Score

Risk Score = Occurrence Score + Geographic Extent Score

Occurrence Score = Hotspots (identified in risk assessment workshop) + SRL + RL + Historical Claims (from MSD). Occurrences were totaled for each grid cell and then the totals were scored on a 0-1 scale.

(# of Occurrences/Minimum # of Occurrences)/Range

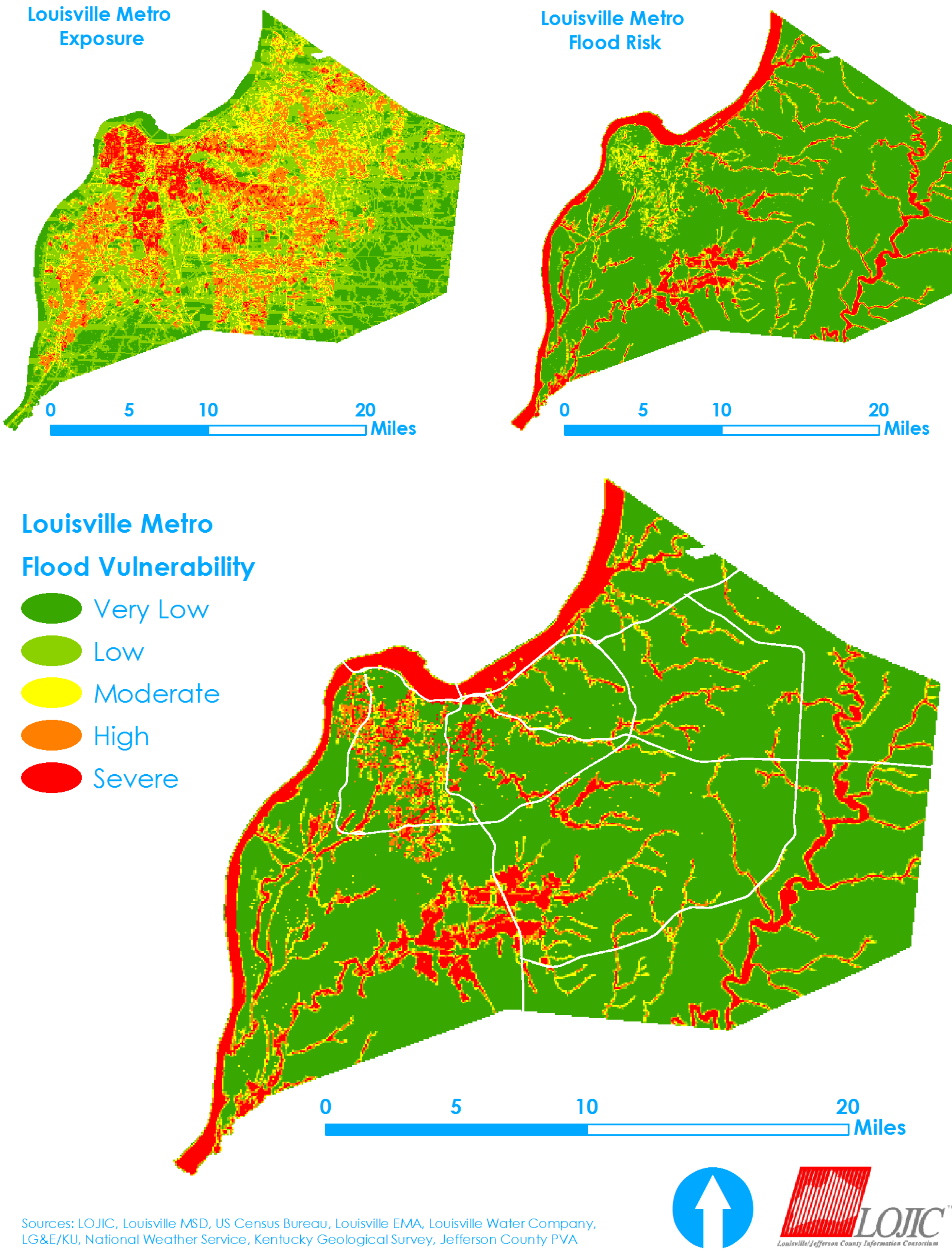
Geographic Extent = % of grid cell in 1% regulatory floodplain and/or in the combined sewer floodprone area (from MSD). Geographic Extent was calculated for each grid cell and then scored on 0-1 scale.

(% of grid cell in floodplain/ minimum % in floodplain)Range

The Occurrence Score was added to the Geographic Extent Score and a new 0-1 score was calculated resulting in the Flood Risk Score.

The Flood Risk Score and the Exposure score were added together and a new 0-1 score was calculated to give the final Flood Vulnerability Score (Figure 18).

Figure 18. Flood Hazard Vulnerability Map



Sources: LOJIC, Louisville MSD, US Census Bureau, Louisville EMA, Louisville Water Company, LG&E/KU, National Weather Service, Kentucky Geological Survey, Jefferson County PVA

4.16.4. Assessing Vulnerability: Identifying Structures and Estimating Potential Losses: Flood

In order to determine structures that are vulnerable and estimated to be damaged during a Flood event the planning team used the Hazard Boundary Overlay methodology. The Hazard Boundaries used as the overlay were the Louisville MSD Regulatory Floodplain and the Combined Sewer Floodprone Area. These Flood potential maps display areas of mapped flood prone areas based on scientific studies, thus displaying areas where potential losses from Floods could occur.

Table 14 describes the total number of structures identified within the Louisville MSD Regulatory Floodplain and the replacement cost of those structures. This model estimates complete damage of each structure located within the Hazard Boundary.

Table 14. Potential Losses from Flood

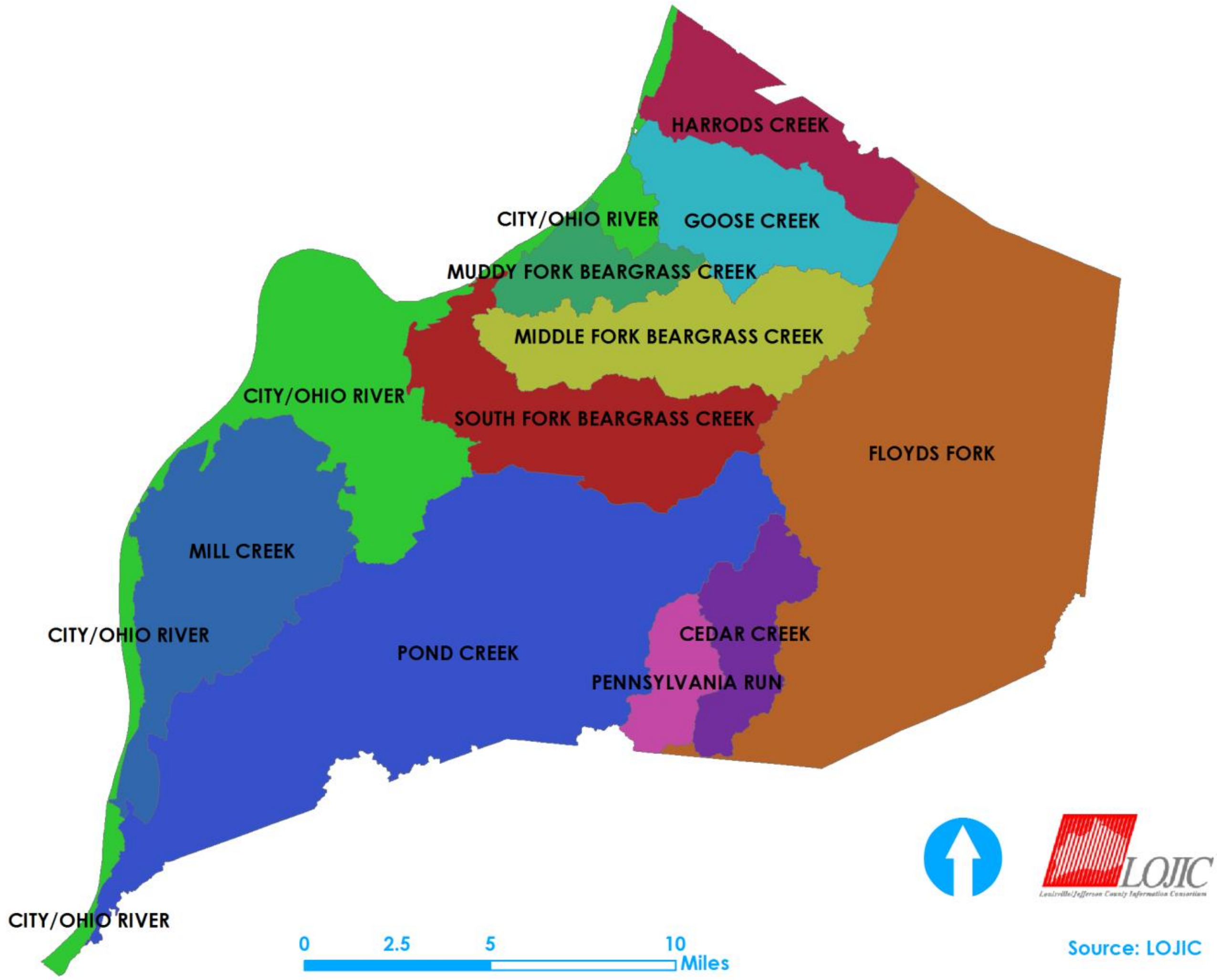
Type	Structures
Agricultural	109
Industrial	683
Commercial	2,735
Residential	14,205
Other	983
Total Structures	**18,715**
Estimated Loss	**$1,403,820,590**

4.16.5. Louisville Metro Watersheds

In June 1997, MSD launched a watershed-based approach to managing its floodplain, wastewater, and stormwater programs. MSD's holistic overview of watershed management integrates service activities such as planning, enforcement, emergency management, best management practices, preservation, hydrology, hydraulics, and geography. The watershed approach also promotes a comprehensive effort to address multiple causes of water quality and habitat degradation in a watershed. In Jefferson County, all streams eventually drain into the Ohio River.

MSD recognizes that each watershed area presents its own set of challenges. Figure 19 depicts Jefferson County's eleven natural watersheds.

Figure 19. Louisville Metro Watersheds



A detailed Risk Assessment was performed for each watershed providing data for the following:

- Identifying Critical/Essential Facilities and Infrastructure located within the Regulatory Floodplain
- Assessing and quantifying natural and beneficial function areas
- Mapping known hazard areas (Regulatory Floodplain, Repetitive Loss Properties, Severe Repetitive Loss, Historic Claim Properties, Flood Hotspots, and the Combined Sewer Floodprone area zones
- Assessing the impact flood will have on life, safety and health facilities and the effects on the communities economy through loss estimation
- Providing a description of known flood hazards, including source of water, depth of flooding, velocities, and identifying key warning time gauges.

4.16.5.1. Watershed Characteristics

Table 15 displays important characteristics for each watershed. Included within the table are the following: drainage area, major stream networks that cause flooding, and the location of USGS stream gauges. The stream gauges provide data that can be useful during all phases of emergency/floodplain management. The gauges are useful in providing early warnings during an event, data for mapping, and water quality data.

Table 15. Watershed Characteristics

11 Watersheds	Drainage Area (sq mi)	Major Stream Systems	USGS Stream Gauges
Middle Fork Beargrass Creek	25.1	Middle Fork Weicher Creek	Middle Fork @ Old Cannons Ln Middle Fork @ Lexington Rd
Muddy Fork Beargrass Creek	8.8	Muddy Fork	Muddy Fork @ Mockingbird Valley Rd
South Fork Beargrass Creek	27.1	South Fork Buechel Branch	South Fork @ Trevilian Way South Fork @ River Rd
Cedar Creek	11.2	Cedar Creek	Cedar Creek @ Thixton Rd
Floyds Fork	103.9	Floyds Fork Chenoweth Run Pope Lick	Floyds Fork @ Old Taylorsville Rd Floyds Fork @ Bardstown Rd Chenoweth Run @ Ruckriegal Pkwy Chenoweth Run @ Gelhaus Ln
Goose Creek	18.6	Goose Creek	Goose Creek @ Old Westport Rd Goose Creek @ US Hwy 42 Little Goose Creek @ US Hwy 42
Harrods Creek	15.3	Harrods Creek Wolf Pen Branch South Fork Harrods South Fork Hite	N/A
Mill Creek(4)	34.2	Mill Creek Upper Mill Creek Big Run Cane Run Black Pond Creek	Mill Creek Cutoff @ Cane Run Rd Mill Creek @ Orell Rd
Ohio River	39.8	Combined Sewer System	Ohio River @ 2nd Street Bridge Ohio River @ McAlpine Locks Ohio River @ Kosmosdale
Pennsylvania Run	6.9	Pennsylvania Run	Penn Run @ Mt Washington Rd
Pond Creek	89.3	Pond Creek Northern Ditch Southern Ditch Fern Creek	Pond Creek @ W Manslick Rd Pond Creek @ Pendleton Rd Northern Ditch @ Preston Hwy Fern Creek @ Old Bardstown Rd Brier Creek @ Pendleton Rd

4.16.5.2. Watershed Flood Risk

In order to understand the flood risk that is within each watershed Project Staff calculated several key requirements in the following tables. Table 16 displays existing buildings located in the regulatory floodplain by watershed. This data can be used to display economic issues based on the potential losses each watershed could observe based on the buildings identified within the floodplain and their corresponding replacement costs.

Table 16. Existing Buildings in the Regulatory Floodplain and Combined Sewer Floodprone Area

Watersheds	Total	Value	Agri-culture	Resi-dential	Comm-ercial	Industrial	Other	Basement
Cedar Creek	49	$1,195,480	0	46	1	0	2	2
City/Ohio River	3,370	$461,247,930	3	2,613	211	209	334	556
Floyds Fork	413	$19,151,950	53	258	17	9	76	59
Goose Creek	150	$18,545,360	1	109	13	0	27	39
Harrods Creek	121	$13,459,920	4	58	19	0	40	31
Middle Fork Beargrass Creek	345	$77,387,590	0	250	54	9	32	101
Mill Creek	2,630	$114,818,250	0	2,396	167	5	62	463
Muddy Fork Beargrass Creek	229	$35,118,810	0	182	20	0	27	97
Pennsylvania Run	120	$4,736,220	2	106	0	0	12	5
Pond Creek	8,675	$459,265,680	41	6,305	1814	354	161	479
South Fork Beargrass Creek	2,613	$198,893,400	5	1,882	419	97	210	454
Total	**18,715**	**$1,403,820,590**	**109**	**14,205**	**2,735**	**683**	**983**	**2,286**

4.16.5.3. Natural and Beneficial Floodplain Functions

Along with flood protection and floodplain management, mitigation plans should discuss the unique natural features, natural areas, and other environmental and aesthetic attributes that may be present in the floodplain. Protecting and preserving these natural and beneficial floodplain functions yield flood mitigation benefits and also help integrate floodplain management efforts with other community goals and objectives.

Table 17 identifies key natural and beneficiary functions located in each watershed. This data showcases areas that need to be preserved and maintained in order to mitigate the effects of the flood risk. The following variables provide unique, natural habitats and are considered beneficial based on their ability to remove water pollutants and to store floodwaters during flood events.

Table 17. Natural & Beneficial Functions

Watershed	Total Acres	Hydric Soils		Open Space		Wetlands		Floodplain	
		Acres	%	Acres	%	Acres	%	Acres	%
Cedar Creek	7,187	243	3.37%	169	2.36%	2	0.02%	271	3.77%
City/Ohio River	25,485	280	1.10%	2,263	8.88%	479	1.88%	5,443	21.36%
Floyds Fork	6,6499	519	0.78%	6,393	9.61%	316	0.47%	6,838	10.28%
Goose Creek	11,894	299	2.51%	1,361	11.44%	3	0.02%	896	7.54%
Harrods Creek	9,789	184	1.88%	1,344	13.73%	43	0.44%	857	8.75%
Middle Fork Beargrass Creek	16,082	48	0.30%	2,128	13.23%	7	0.04%	986	6.13%
Mill Creek	21,902	1,373	6.27%	1,785	8.15%	543	2.48%	2,183	9.97%
Muddy Fork Beargrass Creek	5,643	63	1.12%	562	9.96%	1	0.03%	696	12.33%
Pennsylvania Run	4,452	160	3.59%	932	20.93%	7	0.17%	236	5.31%
Pond Creek	57,150	7,828	13.70%	6,774	11.85%	1,005	1.76%	8,921	15.61%
South Fork Beargrass Creek	17,334	191	1.10%	1,083	6.25%	48	0.28%	1,767	10.20%
Total	**243,416**	**11,188**	**4.60%**	**24,795**	**10.19%**	**2,453**	**1.01%**	**29,095**	**11.95%**

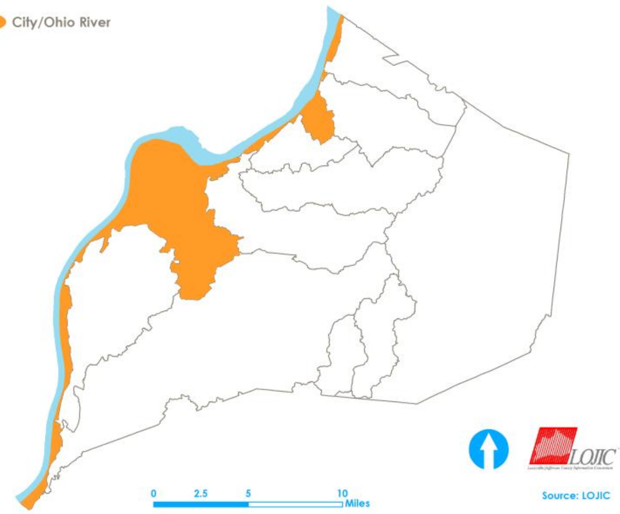
4.16.5.4. Critical Facilities in a Floodplain

Critical Facilities are essential to the health and welfare of the whole population and are especially important following hazard events. Table 18 identifies facilities located in the Regulatory Floodplain that were used in the Exposure Score. The identification of these properties provide prime locations for hazard mitigation project opportunities and also identify potential health and safety problems caused by disaster, such as when the sewer treatment plant is flooded.

Table 18. Critical Facilities in the Floodplain by Watershed

Insert Exposure facilities by watershed table

4.16.6. Watershed Overviews



4.16.6.1. Ohio River/City Watershed

The Ohio River Watershed has an area of approximately 39.8 square miles and contains 49.5 stream miles, most of which are the Main Stem of the Ohio River. This watershed is drained by a complex system of combined sewers. No open channels of any magnitude exist.

The Ohio River Main Stem through Louisville Metro is located along the northwestern border of Jefferson County and the far side of the river is in Indiana. A levee and floodwall system separates the river from the rest of Louisville Metro. The flood protection system includes pump stations and dams at all stream crossings and combined sewer overflows (CSO) outfalls.

Communities situated in this watershed include downtown Louisville, Kenwood, Southern Heights, Beechmont, Oakdale, Wilder Park, Parkland, South Parkland, Shawnee, and Portland. Notable landmarks include the Kentucky Fair and Exposition Center, the University of Louisville, Churchill Downs, Kentucky International Convention Center, City Hall, portions of Iroquois Park, Shawnee Park, and Chickasaw Park.

Many other parks are located along the Ohio River and provide preserved open space along the Ohio River floodplain. These parks include Eva Bandman Park, Capertown Swamp, Chickasaw Park, Carrie Gaulbert Cox Park, Hays Kennedy Park, Kulmer Reserve, Lannan Park, Portland Wharf Park, Riverside Farnsley-Moorman Landing, Riverview Park, Thurman Hutchins Park, Twin Park, and Waterfront Park.

Ohio River and Floodwall

A large portion of Louisville Metro lies within the broad floodplain of the Ohio River; however, about 17,600 acres of this floodplain, including downtown Louisville, are protected by a 28.9 mile long flood protection system. The first phase of the system, which protects the area from Beargrass Creek to just south of Rubbertown, was completed by the Army Corps of Engineers in 1957. A second phase was completed in the late 1980s to protect southwest Louisville Metro, from Rubbertown to Pond Creek. The floodwall system is built to protect Louisville Metro from floods equivalent to the historic flood event of 1937 with three feet of freeboard.

Topography

The major portion of the Ohio River/City Watershed is located in the Flood Plain Topographic Region. The remaining portion lies in the Central Basin. A very flat, low-lying terrain predominates both the Flood Plain and Central Basin Regions. Elevations range from about 382 feet, the pool stage of the Ohio River below the McAlpine Lock and Dam, to about 586 feet in Glenview.

Existing Structural Flood Controls

No open channels of any magnitude exist in this watershed; however, in order to help reduce combined sewer overflows, there are two regional detentions basins located in the Ohio River/City Watershed. These basins are Executive Inn Basin and Brady Lake.

Basic Watershed Flood Information

Depth of Water: Using the Flood Insurance Study (FIS) Flood Profile data for the Ohio River the mean average depth of flooding from the stream bed to the Regulatory Floodplain is 80.8 feet. This data was derived from 35 cross sections on the Ohio River.

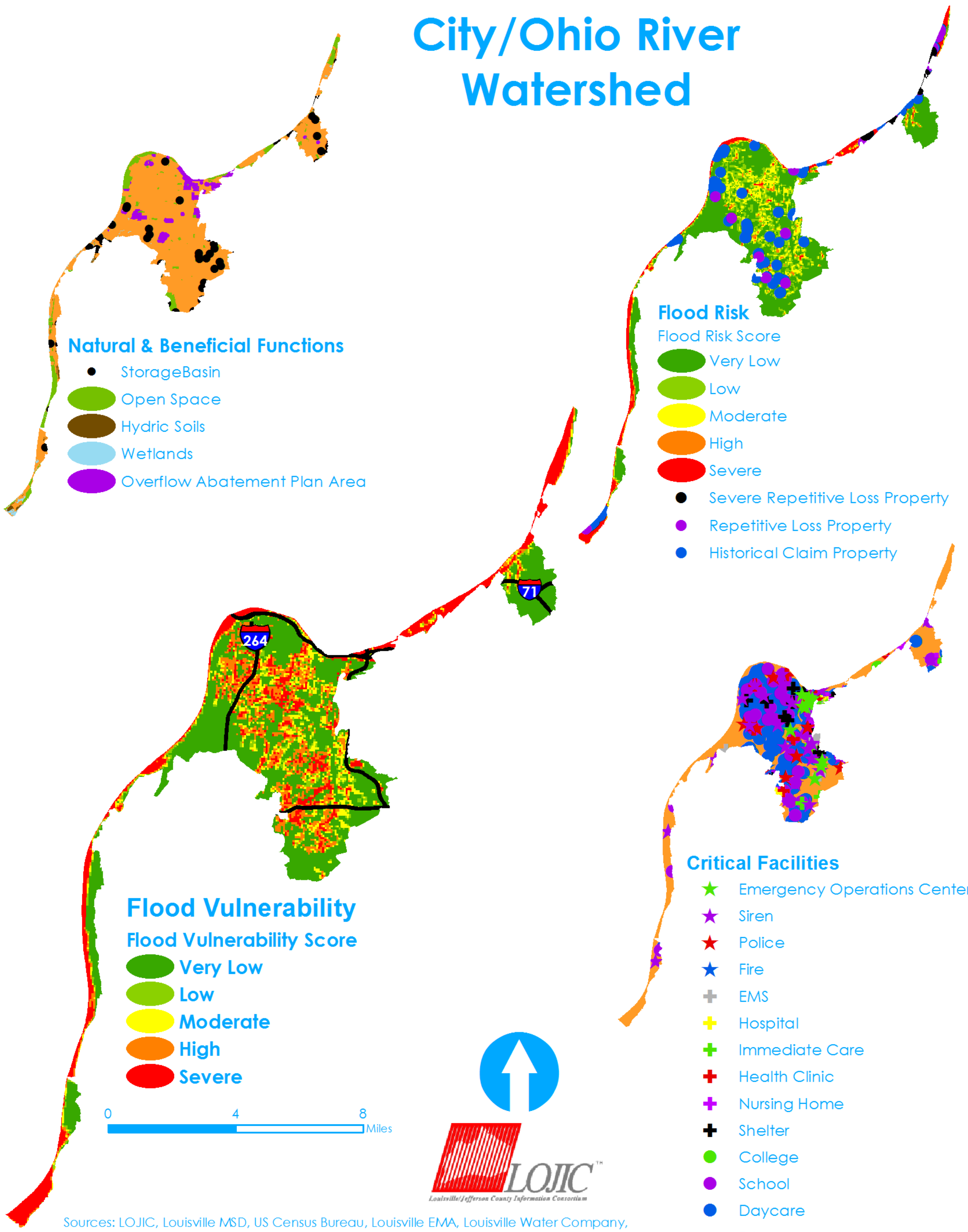
Velocities: Using the FIS Flood Profile data (Floodway) for the Ohio River the mean average velocity is 4.9 feet per second. This data was derived from 35 cross sections on the Ohio River.

Note: The above information is a mean average for the flooding source. Specific locations will provide different outputs throughout the watershed. It should be noted that we can calculate a depth at any point within the floodplain by comparing the ground elevation from the digital terrain model to the flood elevation layer where data permits.

Figure 20 depicts the Ohio River/City Watershed Vulnerability Score. This map details areas of high vulnerability based on several different factors such as: Regulatory Floodplain, Combined Sewer Floodprone Areas, Repetitive Loss Properties, Severe Repetitive Loss, and Historical Claims data. These variables provide a detailed Risk Score that displays areas at risk based on mapped floodplains and mapped occurrence hotspots. These two factors provide Louisville Metro with a comprehensive understanding of where flooding is occurring and potentially causing damage. In addition, Figure 20 displays critical facilities and the natural and beneficial functions for open space and wetlands locations. It is important to note that these maps are for display purposes, to truly use this data one would want to import this data into a GIS program.

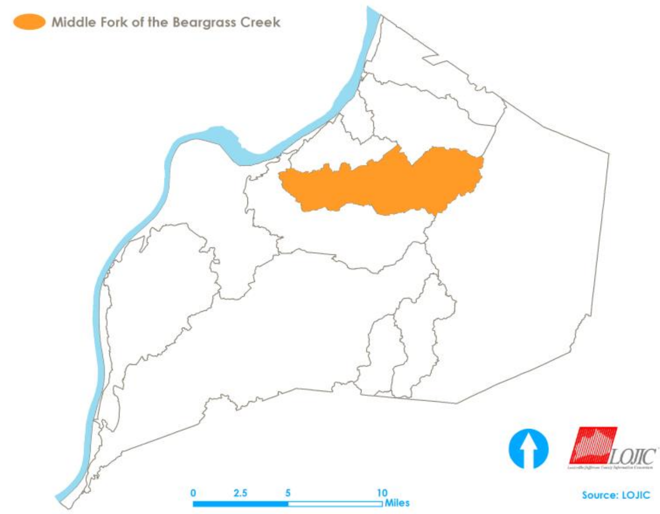
Figure 20. Ohio River/City Watershed

City/Ohio River Watershed



Sources: LOJIC, Louisville MSD, US Census Bureau, Louisville EMA, Louisville Water Company, LG&E/KU, National Weather Service, Kentucky Geological Survey, Jefferson County PVA

4.16.6.2. Middle Fork of the Beargrass Creek Watershed



The Middle Fork of the Beargrass Creek Watershed is located in the north central portion of Louisville Metro and covers about 25 square miles. The headwaters originate in Middletown and flow in a westerly direction through St. Matthews. The stream continues into the Highlands via Seneca and Cherokee Parks, to finally outlet into the South Fork of the Beargrass Creek just south of Main Street.

The Middle Fork headwaters runs through residential neighborhoods, apartment and condominium complexes, three golf courses, a farm, two shopping malls, two parks in St. Matthews, and past hospitals and shopping centers. The creek parallels I-64 as it passes through Seneca Park, flows on down through Cherokee Park and beside a well-traveled greenway where it converges with the South Fork then the Muddy Fork of the Beargrass Creek. The Middle Fork is the least-modified of the urban streams, has a bedrock or stone bed with riffles and pools in the Olmsted parks and is fed by small groundwater springs for much of the year.

The major streams in the Middle Fork of the Beargrass Creek Watershed are Middle Fork and Weicher Creek. Communities lying in this watershed include the Highlands, Seneca Gardens, St. Regis Park, St. Matthews, Lyndon, Wildwood, Hurstbourne, Douglass Hills, and Middletown. Notable landmarks include Cherokee Park, Seneca Park, Cave Hill Cemetery, the Southern Baptist Seminary, Bowman Field, Big Spring Country Club, Oxmoor Mall, and Hurstbourne Country Club.

Several parks are located along the Middle Fork of Beargrass Creek. These parks provide open space where flooding can occur without property damages and allow recreational use during drier periods. Cherokee Park, owned by the Louisville Metro, is located along Middle Fork Beargrass Creek in the Highlands area. The City of St. Matthews owns two parks, Brown Park and Arthur K. Draut Park, located in the floodplain along Middle Fork of Beargrass Creek near Bowling Boulevard. The Draut Park includes wetlands, which help improve the natural and beneficial functions of the floodplains as well as water quality for the creek.

Topography

The entire Middle Fork of the Beargrass Creek Watershed is situated in the Eastern Uplands Topographic Region. Broad steep-sided valleys and flat to gently rolling plateaus dominate the terrain. The Middle Fork has cut deeply into this terrain and flows through a well-entrenched channel where near vertical cliffs are common. Elevations range from about 425 feet, at the confluence with the South Fork of the Beargrass Creek, to about 750 feet, in the Middletown area.

Existing Structural Flood Controls

The Whipps Mill Basin is a regional flood storage basin that is situated in the upper portion of the Middle Fork Watershed. The basin, which was built in 2000, covers a 40-acre site and provides flood protection for hundreds of residents. The Woodlawn Park Basin is another regional basin located in the Middle Fork Watershed.

Basic Watershed Flood Information

Depth of Water: Using the FIS Flood Profile data for Middle Fork Beargrass Creek the mean average depth of flooding from the stream bed to the Regulatory Floodplain is 13.2 feet. This data was derived from 60 cross sections on Middle Fork Beargrass Creek. Using the FIS Flood Profile data for Weicher Creek the mean average depth of flooding from the stream bed to the Regulatory Floodplain is 5.4 feet. This data was derived from 30 cross sections on Weicher Creek.

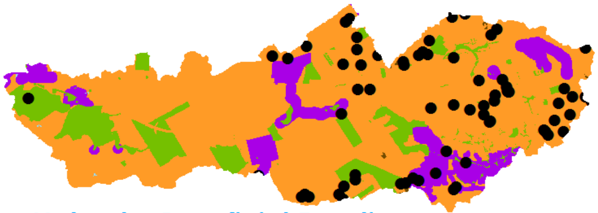
Velocities: Using the FIS Flood Profile data (Floodway) for Middle Fork Beargrass Creek the mean average velocity is 4.9 feet per second. This data was derived from 60 cross sections on the Middle Fork Beargrass Creek. Using the FIS Flood Profile data (Floodway) for Weicher Creek the mean average velocity is 3.8 feet per second. This data was derived from 30 cross sections on Weicher Creek.

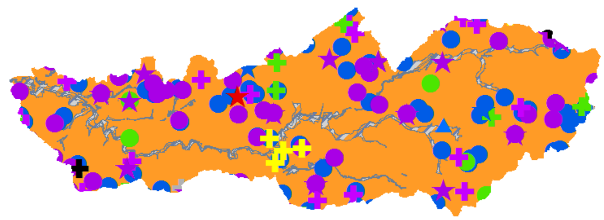
Note: The above information is a mean average for the flooding source. Specific locations will provide different outputs throughout the watershed. It should be noted that we can calculate a depth at any point within the floodplain by comparing the ground elevation from the digital terrain model to the flood elevation layer where data permits.

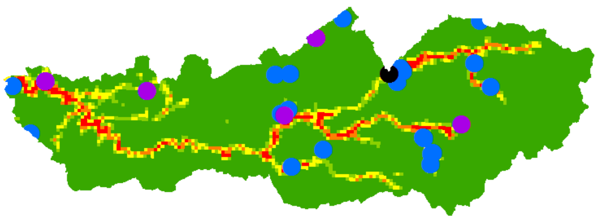
Figure 21 depicts the Middle Fork Beargrass Watershed Vulnerability Score. This map details areas of high vulnerability based on several different factors such as: Regulatory Floodplain, Combined Sewer Floodprone Areas, Repetitive Loss Properties, Severe Repetitive Loss, and Historical Claims data. These variables provide a detailed Risk Score that displays areas at risk based on mapped floodplains and mapped occurrence hotspots. These two factors provide Louisville Metro with a comprehensive understanding of where flooding is occurring and potentially causing damage. In addition, Figure 21 displays critical facilities and the natural and beneficial functions for open space and wetlands locations. It is important to note that these maps are for display purposes, to truly use this data one would want to import this data into a GIS program.

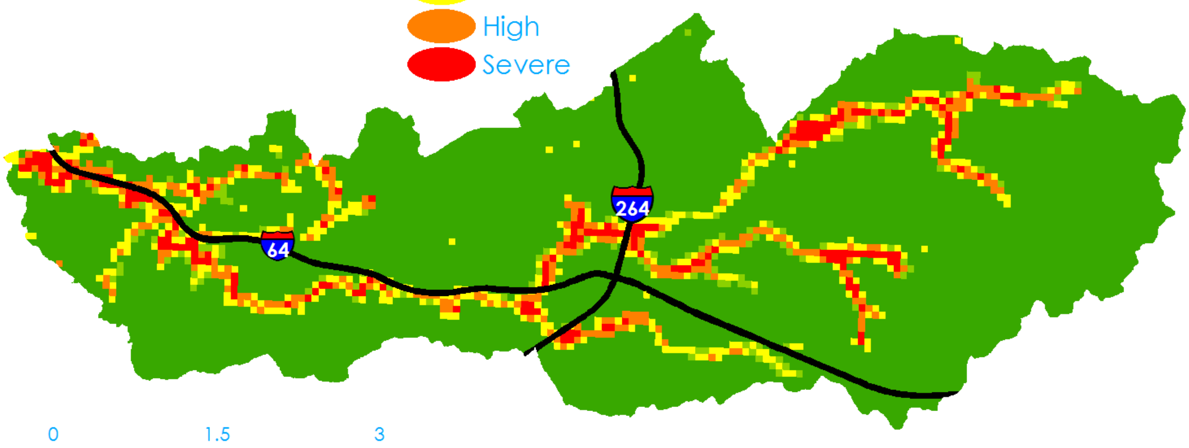
Figure 21. Middle Fork Beargrass Creek Watershed

Middle Fork Beargrass Creek Watershed



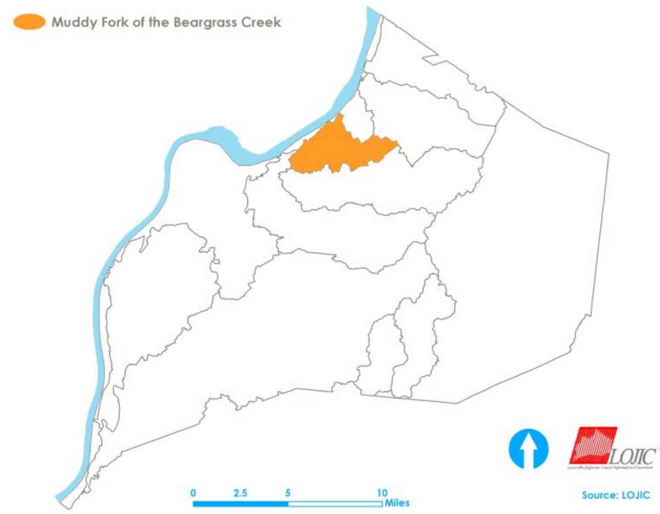






Sources: LOJIC, Louisville MSD, US Census Bureau, Louisville EMA, Louisville Water Company, LG&E/KU, National Weather Service, Kentucky Geological Survey, Jefferson County PVA

4.16.6.3. Muddy Fork of the Beargrass Creek Watershed



The eight square mile Muddy Fork Beargrass Creek Watershed is located in the north central portion of Louisville Metro including Indian Hills and a small part of St. Matthews. Its headwaters originate in the Graymoor/Devondale area. After descending from Indian Hills, Muddy Fork runs parallel to I-71 in the Ohio River floodplain, converging with the Main stem of Beargrass Creek before emptying into the river. Muddy Fork regularly receives backwater from the Ohio River.

Communities lying in this watershed include Graymoor, Devondale, Crescent Hill, Rolling Fields, Mockingbird Valley, Indian Hills, and Windy Hills. Notable landmarks include the VA Hospital, Crescent Hill Park, and the Louisville County Club.

Topography

The major portion of the Muddy Fork Watershed is situated in the Eastern Uplands Topographic Region. Broad steep-sided valleys and gently rolling plateaus dominate the terrain in the Eastern Uplands Region. Muddy Fork has cut deeply into this terrain and flows though a well entrenched channel where near vertical cliffs are common.

The remaining portion, which includes I-71 and land adjacent to the Ohio River, is in the Flood Plain. A flat, low-lying terrain predominates in the floodplain. Stream channels of low gradient slopes tend to parallel the Ohio River. Elevations range from about 420 feet, the pool stage of the Ohio River above the McAlpine Lock and Dam, to about 585 feet, in the Devondale area.

Existing Structural Flood Controls

No regional basins or major channel improvement projects are located in the Muddy Fork Watershed.

Basic Watershed Flood Information

Depth of Water: Currently there is no data that displays depth of water for the Muddy Fork Beargrass Creek watershed. This will be addressed in our 2010 RiskMAP update.

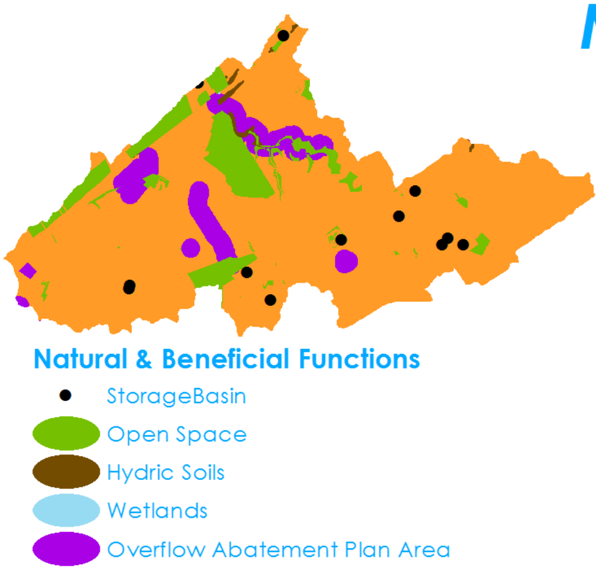
Velocities: Currently there is no data that displays velocities for the Muddy Fork Beargrass Creek watershed. This will be addressed in our 2010 RiskMAP update.

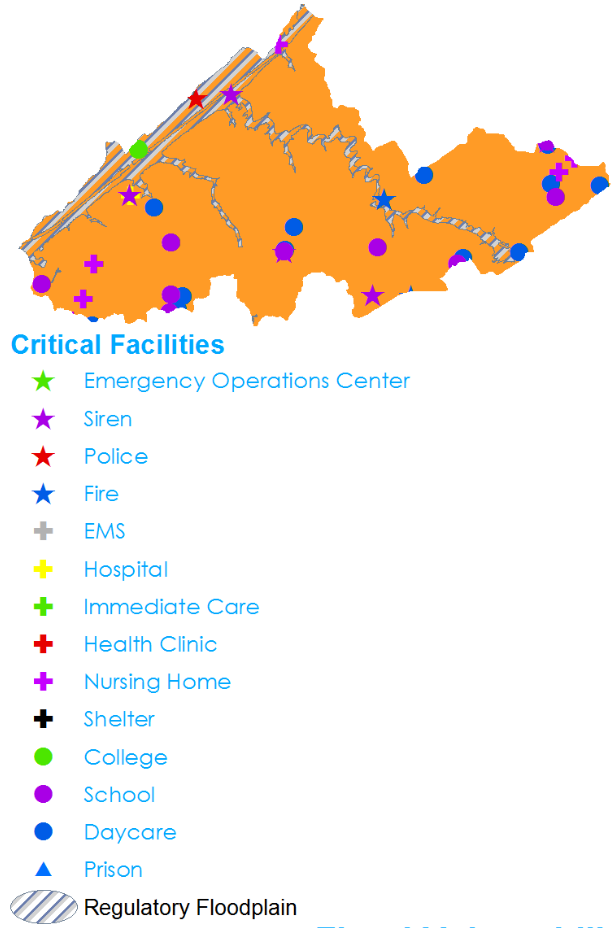
Note: The above information is a mean average for the flooding source. Specific locations will provide different outputs throughout the watershed. It should be noted that we can calculate a depth at any point within the floodplain by comparing the ground elevation from the digital terrain model to the flood elevation layer where data permits.

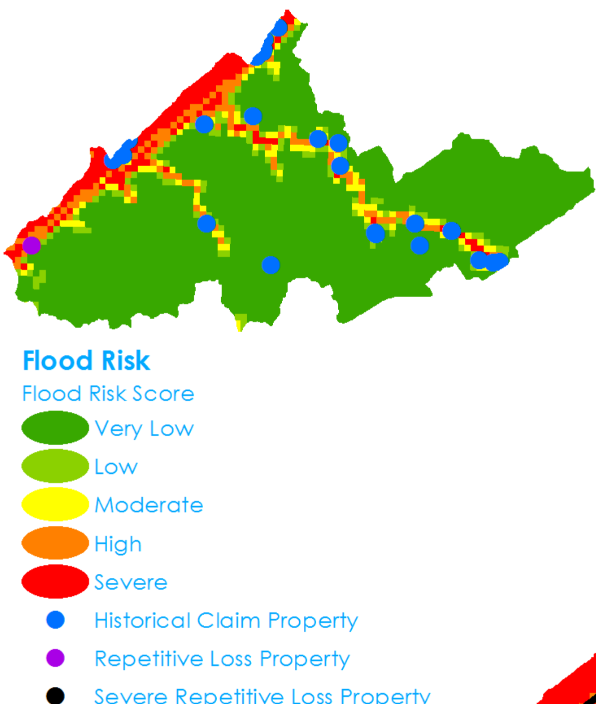
Figure 22 depicts the Muddy Fork Beargrass Watershed Vulnerability Score. This map details areas of high vulnerability based on several different factors such as: Regulatory Floodplain, Combined Sewer Floodprone Areas, Repetitive Loss Properties, Severe Repetitive Loss, and Historical Claims data. These variables provide a detailed Risk Score that displays areas at risk based on mapped floodplains and mapped occurrence hotspots. These two factors provide Louisville Metro with a comprehensive understanding of where flooding is occurring and potentially causing damage. In addition, Figure 22 displays critical facilities and the natural and beneficial functions for open space and wetlands locations. It is important to note that these maps are for display purposes, to truly use this data one would want to import this data into a GIS program.

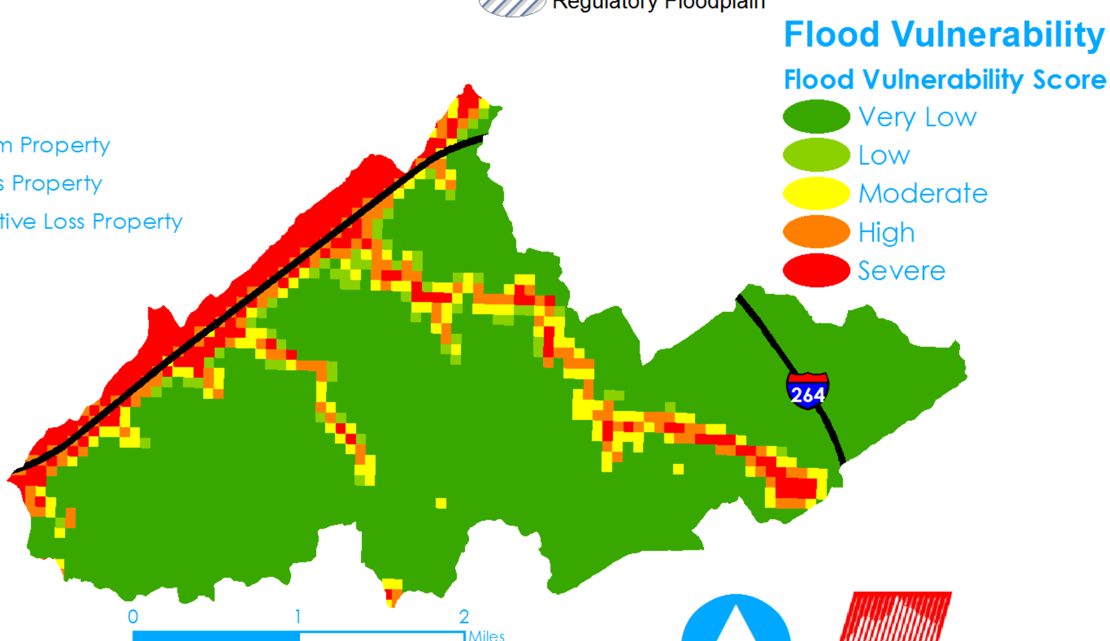
Figure 22. Muddy Fork Beargrass Creek Watershed

Muddy Fork Beargrass Creek Watershed



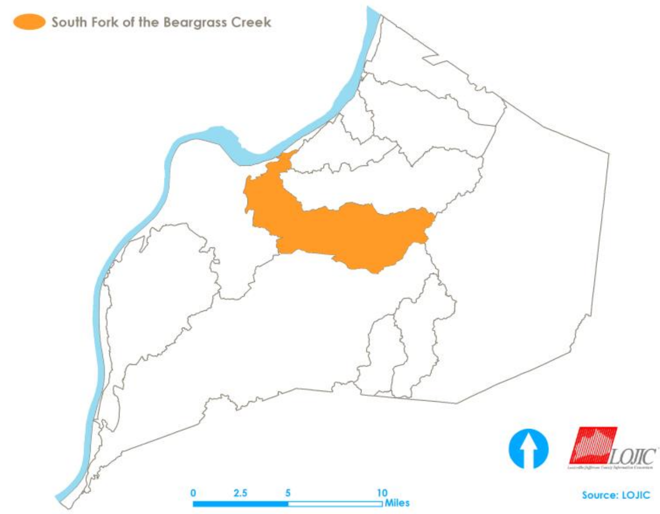






Sources: LOJIC, Louisville MSD, US Census Bureau, Louisville EMA, Louisville Water Company, LG&E/KU, National Weather Service, Kentucky Geological Survey, Jefferson County PVA

4.16.6.4. South Fork of the Beargrass Creek Watershed



The 27 square mile South Fork Beargrass Creek Watershed is located in the north central portion of Louisville Metro. Headwaters originate in Jeffersontown and eventually outlet into the Ohio River near Towhead Island. At about mile 0.75 of South Fork, the Louisville Local Flood Protection Project (Floodwall) crosses the stream. The Beargrass Pumping Station is located at this point.

From approximately mile 1.4 to mile 4.1, the stream is a large concrete channel with high vertical sidewalls. Major streams in this watershed include South Fork Beargrass Creek and Buechel Branch.

The South Fork drains a significant area of residential and institutional properties, parklands, and cemeteries where it flows in a straightened canal between Newburg Road and Poplar Level Road. At Eastern Parkway, South Fork enters the concrete "improved channel" and flows toward downtown Louisville where it joins Middle Fork and becomes the Main Stem.
Some tributaries in older portions of town such as Snead's Branch and the tributary along and under Trevilian Way were enclosed in pipes and converted into sewers during the booming suburban development of the 1890s-1920s. A cave along the creek bank is the only known home of the Louisville Cave Beetle, an endemic species that is listed as a Candidate for endangered species status.

Communities lying in the watershed include Jeffersontown, Phoenix Hill, Germantown, Audubon Park, Strathmoor, Wellington, Buechel, Highgate Springs, Houston Acres, Forest Hills, Schnitzelburg, Smoketown, Shelby Park, Tyler Park, and the Highlands. Notable landmarks include the Beargrass Creek Pumping Station, Calvary Cemetery, the Louisville Zoo, Tyler Park, and Rest Haven Memorial Cemetery. Several parks are located within the floodplain of South Fork Beargrass Creek, including Joe Creason Park and the Beargrass Creek State Nature Preserve. Buechel Park is located along Buechel Branch, a tributary of South Fork Beargrass Creek. These parks provide open space where flooding can occur without property damage, as well as recreational uses during drier periods.

Topography

The major portion of the South Fork Beargrass Creek Watershed is situated in the Eastern Uplands Topographic Region. Broad steep-sided valleys and flat to gently rolling plateaus dominate the terrain in the Uplands Region. South Fork Beargrass Creek has cut deeply into this terrain and flows through a well entrenched channel.
The remaining portion, which lies west of the Louisville and Nashville Railroad and adjacent to the Ohio River, is in the Flood Plain. A very flat, low-lying terrain predominates in the Flood Plain. South Fork Beargrass Creek flows through an improved concrete channel in this region. Elevations range from about 420 feet, the pool stage of the Ohio River above McAlpine Lock and Dam, to about 690 feet, in the area north of Jeffersontown.

Existing Structural Flood Controls

The South Fork Beargrass Creek Flood Protection project was initiated in 2001 and is currently in the final stages of completion. The project was a joint project between the Army Corps of Engineers and MSD and included the construction of eight regional basins, ranging in size from 9 acre-feet to 160 acre-feet of storage, throughout the South Fork Watershed. The project also included 2000 feet of channel improvement, 1900 feet of floodwall around an apartment complex, and environmental features, such as construction of pools and riffles in the channels and planting 9 acres of bottomland hardwoods. The purpose of the project was to help relieve flooding in the South Fork Watershed. The basins are located near Bashford Manor, Breckenridge Lane, Downing Way, Fountain Square, Hikes Lane, Gerald Court, Richlawn Ave, and Old Shepherdsville Road. Another regional basin, the Dry Bed Reservoir, is also located in the South Fork Beargrass Creek Watershed. This basin was constructed in the 1970s to relieve flooding along South Fork.

Basic Watershed Flood Information

Depth of Water:

- Using the FIS Flood Profile data for South Fork Beargrass Creek the mean average depth of flooding from the stream bed to the Regulatory Floodplain is 14.6 feet. This data was derived from 80 cross sections on South Fork Beargrass Creek.
- Using the FIS Flood Profile data for Buechel Branch the mean average depth of flooding from the stream bed to the Regulatory Floodplain is 9.9 feet. This data was derived from 9 cross sections on Buechel Branch.

Velocities:

- Using the FIS Flood Profile data (Floodway) for South Fork Beargrass Creek the mean average velocity is 5.0 feet per second. This data was derived from 80 cross sections on the South Fork Beargrass Creek.
- Using the FIS Flood Profile data (Floodway) for Buechel Branch the mean average velocity is 3.4 feet per second. This data was derived from 9 cross sections on Buechel Branch.

Note: The above information is a mean average for the flooding source. Specific locations will provide different outputs throughout the watershed. It should be noted that we can calculate a depth at any point within the floodplain by comparing the ground elevation from the digital terrain model to the flood elevation layer where data permits.

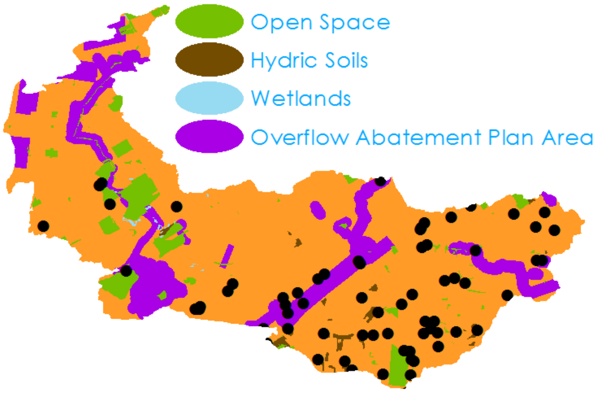
Figure 23 depicts the South Fork Beargrass Watershed Vulnerability Score. This map details areas of high vulnerability based on several different factors such as: Regulatory Floodplain, Combined Sewer Floodprone Areas, Repetitive Loss Properties, Severe Repetitive Loss, and Historical Claims data. These variables provide a detailed Risk Score that displays areas at risk based on mapped floodplains and mapped occurrence hotspots. These two factors provide Louisville Metro with a comprehensive understanding of where flooding is occurring and potentially causing damage. In addition, Figure 23 displays critical facilities and the natural and beneficial functions for open space and wetlands locations. It is important to note that these maps are for display purposes, to truly use this data one would want to import this data into a GIS program.

Figure 23. South Fork Beargrass Creek Watershed

South Fork Beargrass Creek Watershed

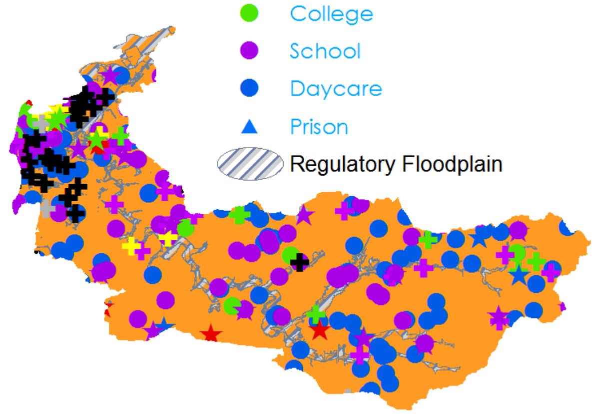
Natural & Beneficial Functions

- StorageBasin
- Open Space
- Hydric Soils
- Wetlands
- Overflow Abatement Plan Area



Critical Facilities

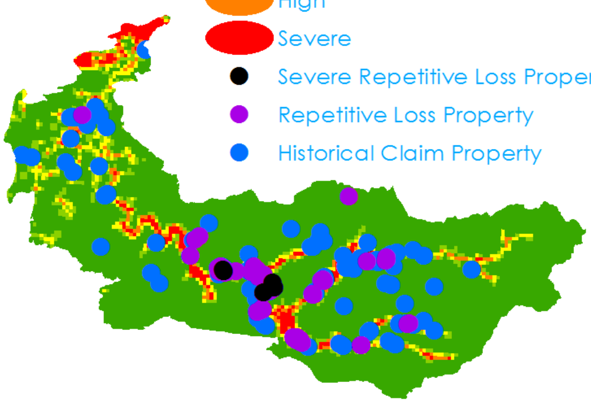
- Emergency Operations Center
- Siren
- Police
- Fire
- EMS
- Hospital
- Immediate Care
- Health Clinic
- Nursing Home
- Shelter
- College
- School
- Daycare
- Prison
- Regulatory Floodplain



Flood Risk

Flood Risk Score

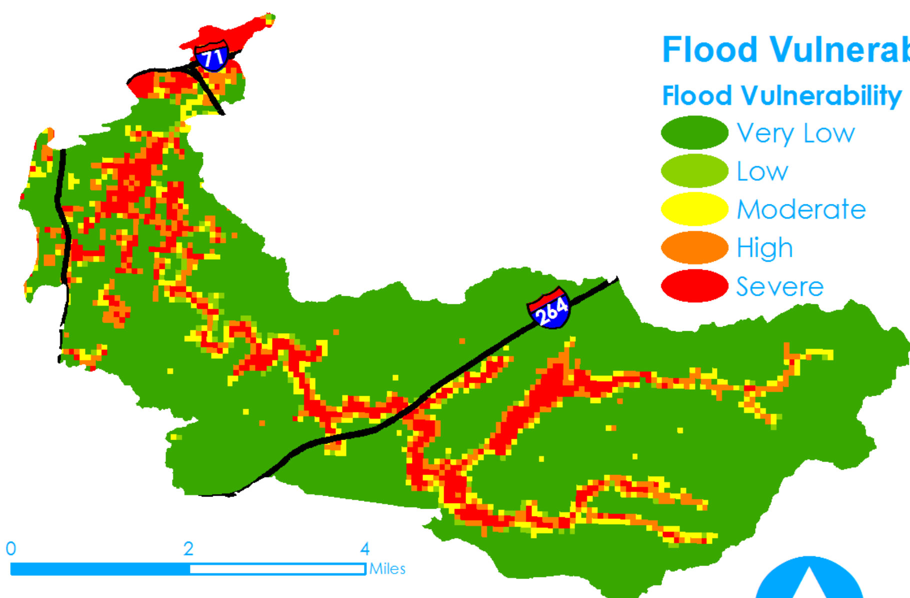
- Very Low
- Low
- Moderate
- High
- Severe
- Severe Repetitive Loss Property
- Repetitive Loss Property
- Historical Claim Property



Flood Vulnerability

Flood Vulnerability Score

- Very Low
- Low
- Moderate
- High
- Severe



Sources: LOJIC, Louisville MSD, US Census Bureau, Louisville EMA, Louisville Water Company, LG&E/KU, National Weather Service, Kentucky Geological Survey, Jefferson County PVA

LOJIC
Louisville/Jefferson County Information Consortium

4.16.6.5. Cedar Creek Watershed

The 11 square mile Cedar Creek Watershed is located in south central Louisville Metro and contains 57.9 miles of streams. Its headwaters originate in the Fern Creek area. The stream flows in a southerly direction, passing into Bullitt County, and eventually discharges into Floyds Fork. Cedar Creek is the only major stream in this watershed.

Communities lying in this watershed include Fern Creek and Highview. Notable landmarks include Beulah Church and Fern Creek High School.

Also located in this watershed is the Cedar Creek Regional Wastewater Treatment Plant.

Topography

The entire Cedar Creek Watershed is situated in the Eastern Uplands Topographic Region. Broad, fairly steep-sided valleys and narrow ridge crests dominate the terrain. Streams have cut deeply into this terrain and flow through the well-entrenched channels. Elevations range from about 550 feet, at the Jefferson County/Bullitt line.

Existing Structural Flood Controls

The Cedar Creek Watershed has no regional basins or major channel improvement projects.
Basic Watershed Flood Information

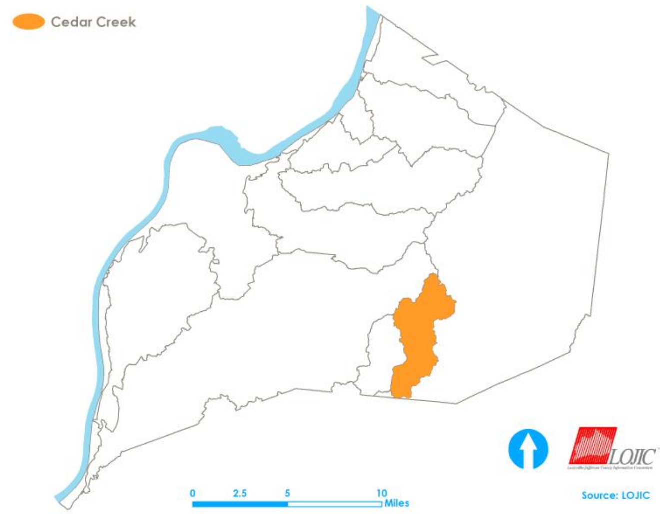
Depth of Water: Using the FIS Flood Profile data for Cedar Creek the mean average depth of flooding from the stream bed to the Regulatory Floodplain is 23.5 feet. This data was derived from 20 cross sections on Cedar Creek.

Velocities: Currently there is no data that displays velocities for the Cedar Creek watershed.

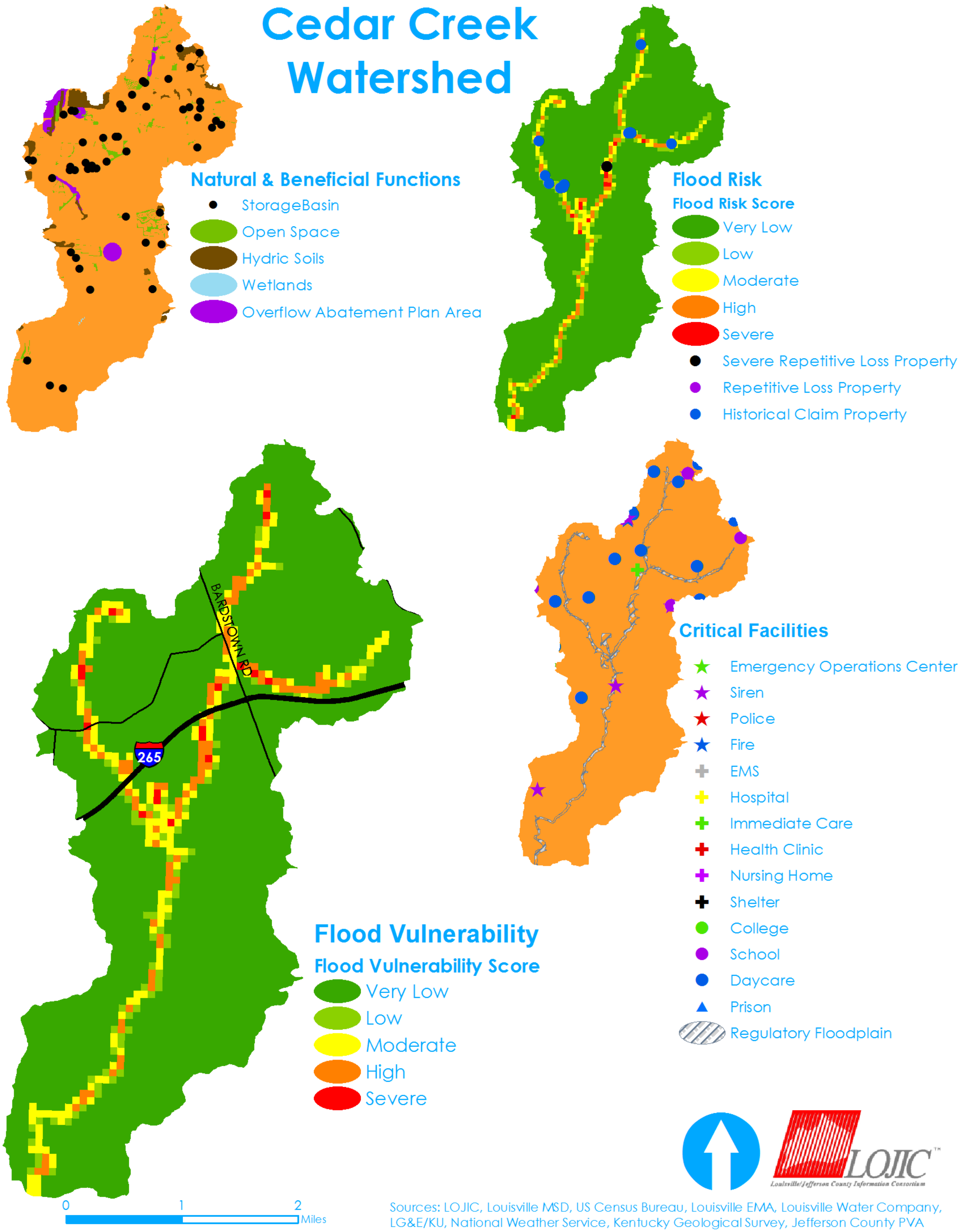
Note: The above information is a mean average for the flooding source. Specific locations will provide different outputs throughout the watershed. It should be noted that we can calculate a depth at any point within the floodplain by comparing the ground elevation from the digital terrain model to the flood elevation layer where data permits.

Figure 24 depicts the Cedar Creek Watershed Vulnerability Score. This map details areas of high vulnerability based on several different factors such as: Regulatory Floodplain, Combined Sewer Floodprone Areas, Repetitive Loss Properties, Severe Repetitive Loss, and Historical Claims data. These variables provide a detailed Risk Score that displays areas at risk based on mapped floodplains and mapped occurrence hotspots. These two factors provide Louisville Metro with a comprehensive understanding of where flooding is occurring and potentially causing damage. In addition, Figure 24 displays critical facilities and the natural and beneficial functions for open space and wetlands locations. It is important to note that these maps are for display purposes, to truly use this data one would want to import this data into a GIS program.

Figure 24. Cedar Creek Watershed

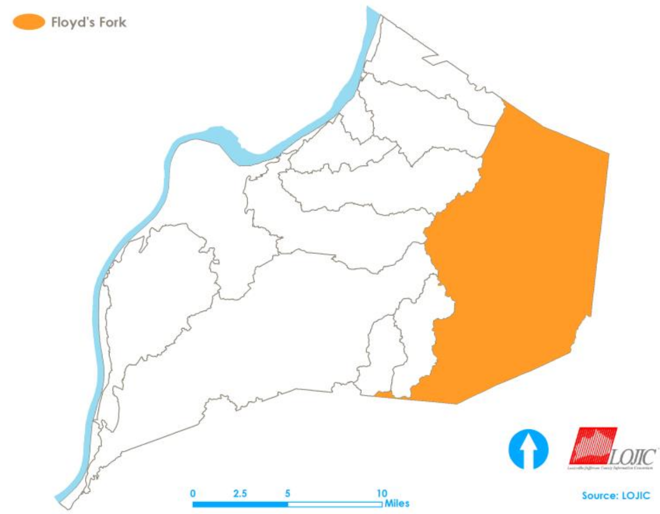


Cedar Creek Watershed



Sources: LOJIC, Louisville MSD, US Census Bureau, Louisville EMA, Louisville Water Company, LG&E/KU, National Weather Service, Kentucky Geological Survey, Jefferson County PVA

4.16.6.6. Floyd's Fork Watershed



The Floyds Fork Watershed is located in eastern Jefferson County, Henry, Oldham, Shelby, Spencer, and Bullitt Counties. Its headwaters originate in southwest Henry County, approximately 13 miles beyond the Louisville Metro boundary line. Flow is generally southwest through Oldham, Shelby, and Jefferson Counties, and then into Bullitt county, where it outlets into the Salt River. The major streams in this watershed are Floyds Fork, Pope Lick, and Chenoweth Run.

Floyds Fork is the largest watershed in Louisville Metro, covering approximately 103.9 square miles and containing 673.2 stream miles. Foyds Fork, which has a total watershed area of 460 square miles, originates in Trimble County (East Fork), and flows west through Oldham County and enters into Louisville Metro at Ash avenue.

Chenoweth Run is a tributary of Floyds Fork, which originates in the Middletown area and flows south and merging into Floyds Fork. The headwater portion of Chenoweth Run watershed is heavily developed.

Communities in the area include parts of Jeffersontown, Middletown, Anchorage, Berrytown, Woodland Hills, Tucker Station, and Hopewell. Notable landmarks include Fishermens Park, Chenoweth Park, Valhalla Golf Course, Midland Trail Golf Course, parts of Bluegrass Industrial Park, Eastern High School, and Jeffersontown High School. Existing parks along Floyds Fork include Floyds Fork Park and William F. Miles Park. Both of these parks provide open space that will be preserved along Floyds Fork.

The City of Parks, Future Fund, and 21st Century Parks are purchasing and preserving much of the floodplain along the creeks.

Topography

The watershed is situated in the Eastern Uplands Topographic Region. Broad, steep-sided valleys and narrow ridge crests dominate the terrain. Major streams have cut deeply into this terrain and flow through well-entrenched channels, where near-vertical cliffs are common. Elevations range from about 490, in the area of the Seatonville Springs Country Club, to about 760 feet, in the area north of Anchorage.

Existing Structural Flood Controls

There are no regional basins or major channel improvement projects located in the Floyds Fork Watershed.

Basic Watershed Flood Information

Depth of Water: Using the FIS Flood Profile data for Floyds Fork the mean average depth of flooding from the stream bed to the Regulatory Floodplain is 22.3 feet. This data was derived from 51 cross sections on Floyds Fork.

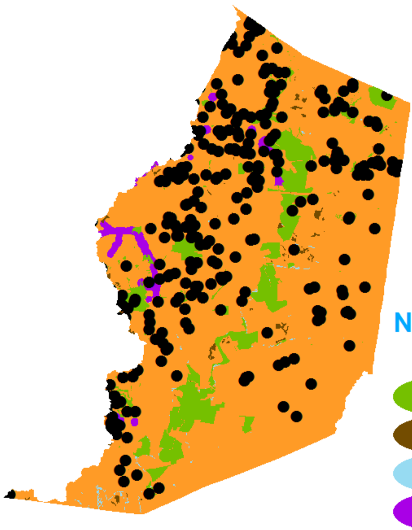
Velocities: Using the FIS Flood Profile data (Floodway) for Floyds Fork the mean average velocity is 4.9 feet per second. This data was derived from 51 cross sections on the Floyds Fork.

Note: The above information is a mean average for the flooding source. Specific locations will provide different outputs throughout the watershed. It should be noted that we can calculate a depth at any point within the floodplain by comparing the ground elevation from the digital terrain model to the flood elevation layer where data permits.

Figure 25 depicts the Floyd's Fork Watershed Vulnerability Score. This map details areas of high vulnerability based on several different factors such as: Regulatory Floodplain, Combined Sewer Floodprone Areas, Repetitive Loss Properties, Severe Repetitive Loss, and Historical Claims data. These variables provide a detailed Risk Score that displays areas at risk based on mapped floodplains and mapped occurrence hotspots. These two factors provide Louisville Metro with a comprehensive understanding of where flooding is occurring and potentially causing damage. In addition, Figure 25 displays critical facilities and the natural and beneficial functions for open space and wetlands locations. It is important to note that these maps are for display purposes, to truly use this data one would want to import this data into a GIS program.

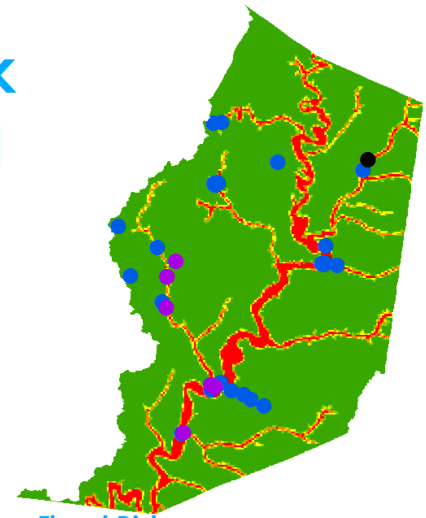
Figure 25. Floyd's Fork Watershed

Floyd's Fork Watershed



Natural & Beneficial Functions

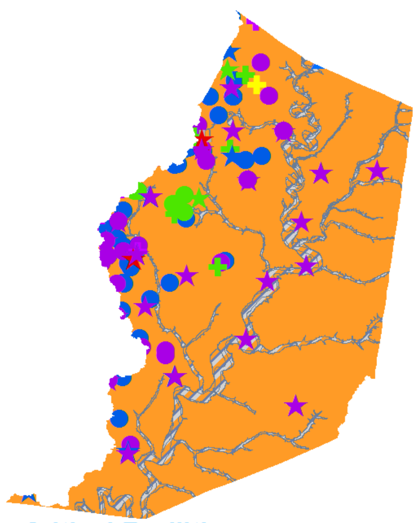
- StorageBasin
- Open Space
- Hydric Soils
- Wetlands
- Overflow Abatement Plan Area



Flood Risk

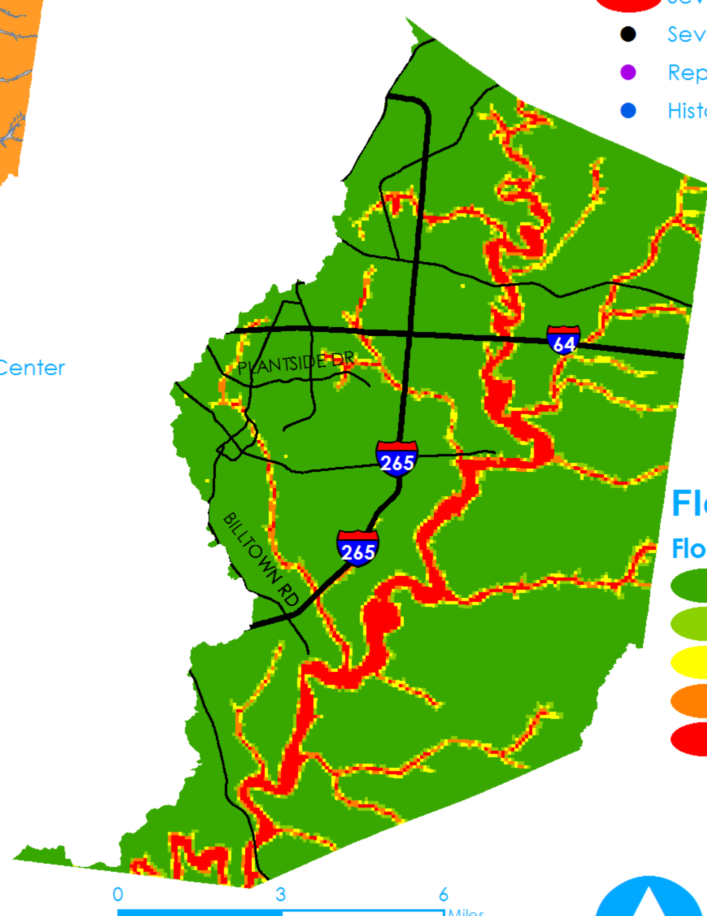
Flood Risk Score

- Very Low
- Low
- Moderate
- High
- Severe
- Severe Repetitive Loss Property
- Repetitive Loss Property
- Historical Claim Property



Critical Facilities

- Emergency Operations Center
- Siren
- Police
- Fire
- EMS
- Hospital
- Immediate Care
- Health Clinic
- Nursing Home
- Shelter
- College
- School
- Daycare
- Prison
- Regulatory Floodplain



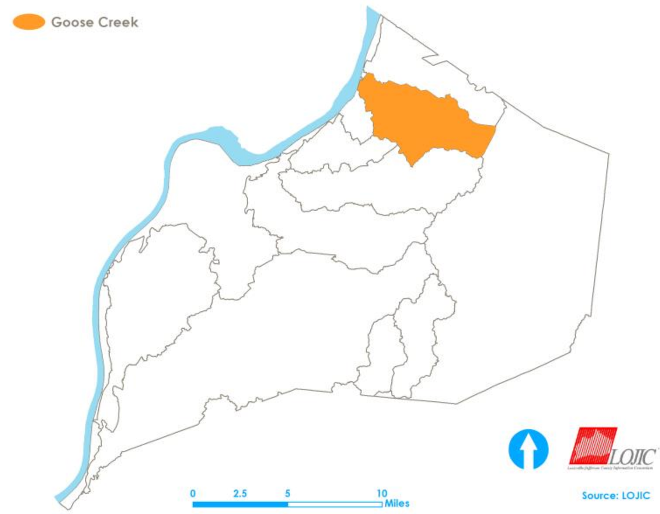
Flood Vulnerability

Flood Vulnerability Score

- Very Low
- Low
- Moderate
- High
- Severe

Sources: LOJIC, Louisville MSD, US Census Bureau, Louisville EMA, Louisville Water Company, LG&E/KU, National Weather Service, Kentucky Geological Survey, Jefferson County PVA

4.16.6.7. Goose Creek Watershed



The Goose Creek of the Ohio River Watershed has an area of approximately 18.5 square miles and contains Goose Creek of the Ohio River and Little Goose Creek of Goose Creek. The 18 square mile Goose Creek Watershed is located in northeastern Louisville Metro and is drained primarily by Goose Creek and Little Goose Creek.

Goose Creek's headwaters originate in Anchorage, flow in a westerly direction to the area of Westport Middle School, then turn generally northwest, and finally outlet into the Ohio River at Six Mile Island.

Little Goose Creek's headwaters originate in the Freys Hill area, flow northwesterly, and eventually discharge into Goose Creek about one-half mile from its outlet on the Ohio River.

Communities situated in this watershed include Anchorage, Rolling Hills, Plantation, Old Brownsboro Place, Hills and Dales, Glenview Heights, Brownsboro Farm, and Green Spring. Notable landmarks include Kentucky Country Day School, E.P. Tom Sawyer State Park, Owl Creek Country Club, Central State Hospital, Standard Country Club, and Ballard High School. Hounz Lane Park is located along Goose Creek and provides open space and wetland areas that will be preserved. E.P. "Tom" Sawyer State Park is another park located along Goose Creek that provides open space that will be preserved.

Topography

The major portion of the Goose Creek Watershed is situated in the Eastern Uplands Topographic Region. Broad, fairly steep-sided valleys and gently rolling plateaus dominate the terrain in the Uplands Region. Both Goose and Little Goose Creek have cut deeply into this terrain and they flow through well entrenched, channels, where near vertical cliffs are common.

The remaining portion, which lies adjacent to the Ohio River, is in the Flood Plain. A flat, low-lying terrain predominates in the Flood Plain Region. Excluding Goose Creek, stream channels of low gradient slopes tend to parallel the Ohio River. Elevations range from about 420 feet, the pool stage of the Ohio River at the McAlpine Lock and Dam, to about 760 feet, in the area north of Anchorage.

Existing Structural Flood Controls

There are no regional basins or major channel improvement projects located in the Goose Creek Watershed.

Basic Watershed Flood Information

Depth of Water: Using the FIS Flood Profile data for Goose Creek the mean average depth of flooding from the stream bed to the Regulatory Floodplain is 4.9 feet. This data was derived from 23 cross sections on Goose Creek.

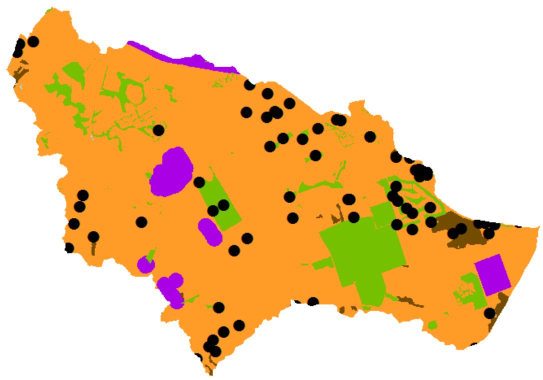
Velocities: Using the FIS Flood Profile data (Floodway) for Goose Creek the mean average velocity is 4.7 feet per second. This data was derived from 23 cross sections on the Goose Creek.

Note: The above information is a mean average for the flooding source. Specific locations will provide different outputs throughout the watershed. It should be noted that we can calculate a depth at any point within the floodplain by comparing the ground elevation from the digital terrain model to the flood elevation layer where data permits.

Figure 26 depicts the Goose Creek Watershed Vulnerability Score. This map details areas of high vulnerability based on several different factors such as: Regulatory Floodplain, Combined Sewer Floodprone Areas, Repetitive Loss Properties, Severe Repetitive Loss, and Historical Claims data. These variables provide a detailed Risk Score that displays areas at risk based on mapped floodplains and mapped occurrence hotspots. These two factors provide Louisville Metro with a comprehensive understanding of where flooding is occurring and potentially causing damage. In addition, Figure 26 displays critical facilities and the natural and beneficial functions for open space and wetlands locations. It is important to note that these maps are for display purposes, to truly use this data one would want to import this data into a GIS program.

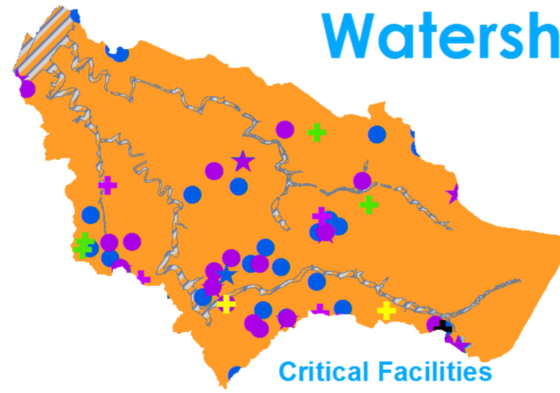
Figure 26. Goose Creek Watershed

Goose Creek Watershed



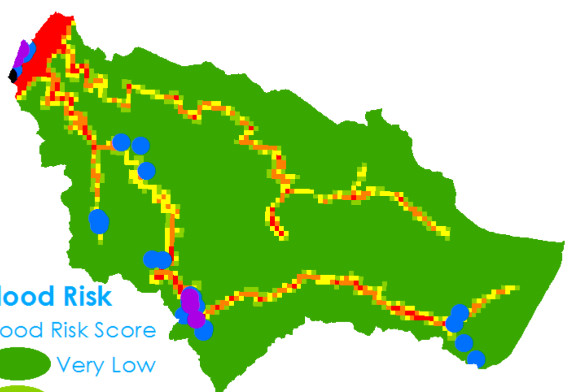
Natural & Beneficial Functions

- StorageBasin
- Open Space
- Hydric Soils
- Wetlands
- Overflow Abatement Plan Area



Critical Facilities

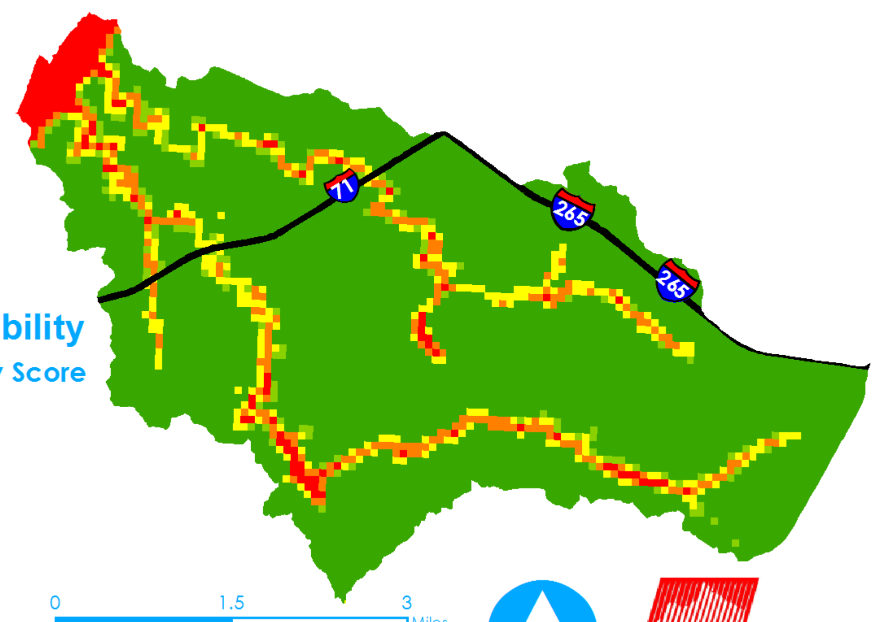
- Emergency Operations Center
- Siren
- Police
- Fire
- EMS
- Hospital
- Immediate Care
- Health Clinic
- Nursing Home
- Shelter
- College
- School
- Daycare
- Prison
- Regulatory Floodplain



Flood Risk

Flood Risk Score

- Very Low
- Low
- Moderate
- High
- Severe
- Severe Repetitive Loss Property
- Repetitive Loss Property
- Historical Claim Property



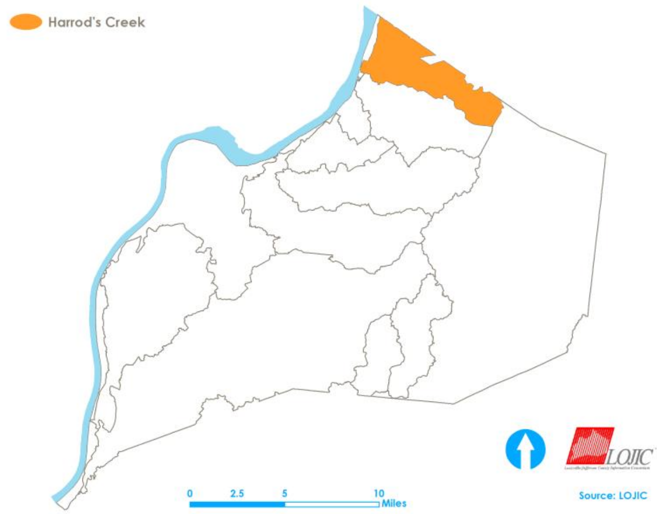
Flood Vulnerability

Flood Vulnerability Score

- Very Low
- Low
- Moderate
- High
- Severe

Sources: LOJIC, Louisville MSD, US Census Bureau, Louisville EMA, Louisville Water Company, LG&E/KU, National Weather Service, Kentucky Geological Survey, Jefferson County PVA

4.16.6.8. Harrod's Creek Watershed



The 180 square mile Harrods Creek Watershed is located in northeastern Jefferson County, Oldham, and Henry Counties. Its headwaters originate in the area east of LaGrange, KY, approximately 17 miles beyond the Jefferson County border. The creek flows generally to the southwest, converging with South Fork Harrods Creek about one-half mile outside the Louisville Metro line. From this point, the flow continues southwest through Louisville Metro to an outlet on the Ohio River at Guthrie Beach. Major streams in this watershed include Harrods Creek, Wolf Pen Branch, South Fork Harrods Creek, and South Fork Hite Creek.

Only 15.3 square miles of the Harrods Creek Watershed lies within Louisville Metro. Wolf Pen Branch, a tributary of Harrods Creek, originates in the Worthington area and flows northwest merging into Harrods Creek and eventually flowing into the Ohio River.

Communities in the study area include Fincastle, Ballardsville, Pewee Valley, Lake Louisvilla, Worthington, and Prospect. Notable landmarks include the Ford Motor Company Kentucky Truck Plant and Hunting Creek Country Club.

Topography

The major portion of the watershed is situated in the Eastern Uplands Topographic Region. The remaining portion lies adjacent to the Ohio River and is in the Flood Plain.

Broad steep-sided valleys and gently rolling plateaus dominate the terrain in the Uplands Region. Harrods Creek has cut deeply into this terrain and it flows through a well-entrenched channel, where near-vertical cliffs are common. A very flat, low-lying terrain predominates in the Flood Plain, excluding Harrods Creek, stream channels of low gradient slopes tend to parallel the Ohio River. Elevations range from about 420 feet, the pool stage of the Ohio River above the McAlpine Lock and Dam, to about 780 feet, in an area southwest of Pewee Valley.

Existing Structural Flood Control

No regional basins or major channel improvement projects are located in the Harrods Creek Watershed.

Basic Watershed Flood Information

Depth of Water: Using the FIS Flood Profile data for Harrods Creek the mean average depth of flooding from the stream bed to the Regulatory Floodplain is 41 feet. This data was derived from 49 cross sections on Harrods Creek. Using the FIS Flood Profile data for South Fork Hite Creek the mean average depth of flooding from the stream bed to the Regulatory Floodplain is 8.2 feet. This data was derived from 39 cross sections on South Fork Hite Creek.

Velocities: Using the FIS Flood Profile data (Floodway) for Harrods Creek the mean average velocity is 7.3 feet per second. This data was derived from 49 cross sections on the Harrods Creek.

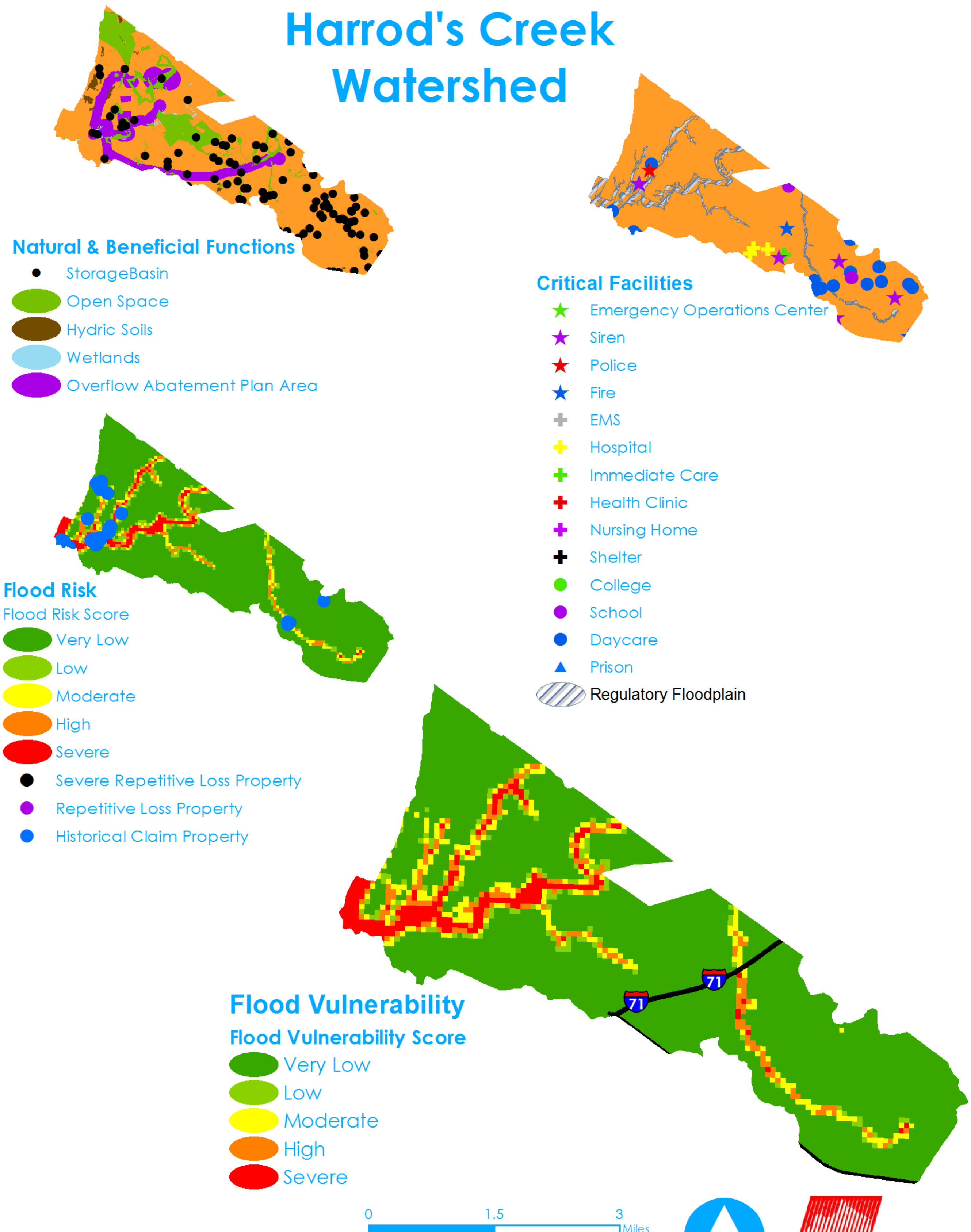
Using the FIS Flood Profile data (Floodway) for South Fork Hite Creek the mean average velocity is 4.0 feet per second. This data was derived from 39 cross sections on the Harrods Creek.

Note: The above information is a mean average for the flooding source. Specific locations will provide different outputs throughout the watershed. It should be noted that we can calculate a depth at any point within the floodplain by comparing the ground elevation from the digital terrain model to the flood elevation layer where data permits.

Figure 27 depicts the Harrod's Creek Watershed Vulnerability Score. This map details areas of high vulnerability based on several different factors such as: Regulatory Floodplain, Combined Sewer Floodprone Areas, Repetitive Loss Properties, Severe Repetitive Loss, and Historical Claims data. These variables provide a detailed Risk Score that displays areas at risk based on mapped floodplains and mapped occurrence hotspots. These two factors provide Louisville Metro with a comprehensive understanding of where flooding is occurring and potentially causing damage. In addition, Figure 27 displays critical facilities and the natural and beneficial functions for open space and wetlands locations. It is important to note that these maps are for display purposes, to truly use this data one would want to import this data into a GIS program.

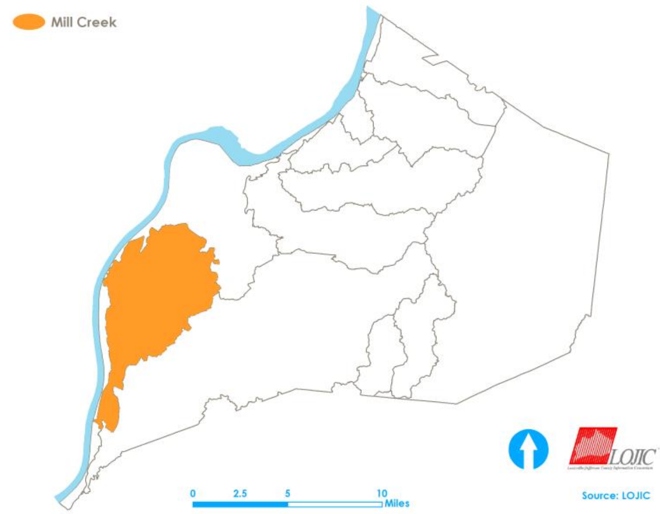
Figure 27. Harrod's Creek Watershed

Harrod's Creek Watershed



Sources: LOJIC, Louisville MSD, US Census Bureau, Louisville EMA, Louisville Water Company, LG&E/KU, National Weather Service, Kentucky Geological Survey, Jefferson County PVA

4.16.6.9. Mill Creek Watershed



The 34 square mile Mill Creek Watershed is located in the western portion of Louisville Metro and contains 156.8 stream miles, most of it is in modified drainage channels. The Mill Creek Cutoff was constructed many years ago to re-route the upper watershed directly to the Ohio River. The Mill Creek Cutoff collects stormwater from the north end of Iroquois Park, Pleasure Ridge Park and Shively areas.

Due to the diversion of the upstream reaches of Mill Creek into the cut-off channel, this watershed is divided into two entirely separate sections: Upper Mill Creek and Lower Mill Creek. Major streams included in Upper Mill Creek include Big Run, Cane Run, and Mill Creek Cutoff. Major streams included in Lower Mill Creek include Mill Creek and Black Pond Creek.

The 19 square mile Upper Mill Creek's headwaters originate in the area of Manslick Road and I-264. From here, they flow in a westerly direction to the western side of Shively, where several tributaries including Cane Run, Boxwood Ditch, Lynnview Ditch, and Big Run join the flow. From this point, the flow direction is to the northwest, via the cutoff channel. The stream outlets into the Ohio River just south of Riverside Gardens. A flood pumping station is located in the Riverside Gardens area near the stream outlet. This flood pumping station is part of the flood levee system that protects Louisville Metro from Ohio River flooding.

The 15 square mile Lower Mill Creek's headwaters originate in the area of Lower Hunters Trace and Terry Road. From here, the flow is generally to the south, paralleling the Ohio River. Several tributaries, including Black Pond Creek and Valley Creek, join this flow in the Valley Downs area. The stream eventually outlets into the Ohio River west of Valley Village. A flood pumping station is located 0.75 miles upstream of the mouth of Lower Mill Creek. This flood pumping station is part of the flood levee system that protects Louisville Metro from Ohio River flooding.

Communities lying in the Upper Mill Creek section include Shively, Heatherfield, Hunters Trace, Parkwood, St. Denis, and Riverside Gardens. Notable landmarks include Louisville Gas & Electric's Mill Creek Power Station, Western High School, Doss High School, Shively Park, Dixie Manor, and a part of Iroquois Park. Sun Valley Park is located on Mill Creek near Lower River Road. This park provides preserved open space along Mill Creek.

Communities lying in the Lower Mill Creek section include Valley Village, Meadow Lawn, Valley Downs, parts of Valley Station and Pleasure Ridge Park, Sylvania, Greenwood, and Waverly Hills. Notable landmarks include Sun Valley Community Park, Valley High School, Waverly Park, and the Louisville and Jefferson County Riverport Authority.

Topography

The major portion of the Mill Creek Watershed is situated in the Flood Plain Topographic Region. The remaining portion, east of the Illinois Central Railroad, lies in the Knobs. A very flat, low-lying terrain predominates in the Flood Plain. Stream channels with low gradient slopes tend to parallel the Ohio River. Terraces of ten to twenty feet in height are common.

Steep-sided, round-topped hills dominate the terrain in the Knobs. Stream channels are deeply cut into these hills and commonly have high gradient slopes. Elevations range from about 382 feet, the pool stage of the Ohio River below the McAlpine Lock and Dam, to about 760 feet, at the top of the Iroquois Park hill.

Existing Structural Flood Controls

The Wheeler Basin is a regional basin located in the Mill Creek Watershed. The basin was constructed to relieve flooding from the combined sewer system.

Basic Watershed Flood Information

Depth of Water:

- Using the FIS Flood Profile data for Upper Mill Creek the mean average depth of flooding from the stream bed to the Regulatory Floodplain is 16.3 feet. This data was derived from 10 cross sections on Upper Mill Creek.
- Using the FIS Flood Profile data for Big Run Creek the mean average depth of flooding from the stream bed to the Regulatory Floodplain is 9.6 feet. This data was derived from 8 cross sections on Big Run Creek.
- Using the FIS Flood Profile data for Cane Run Ditch the mean average depth of flooding from the stream bed to the Regulatory Floodplain is 10.0 feet. This data was derived from 6 cross sections on Cane Run Ditch.
- Using the FIS Flood Profile data for Black Pond Creek the mean average depth of flooding from the stream bed to the Regulatory Floodplain is 11.7 feet. This data was derived from 9 cross sections on Black Pond Creek.

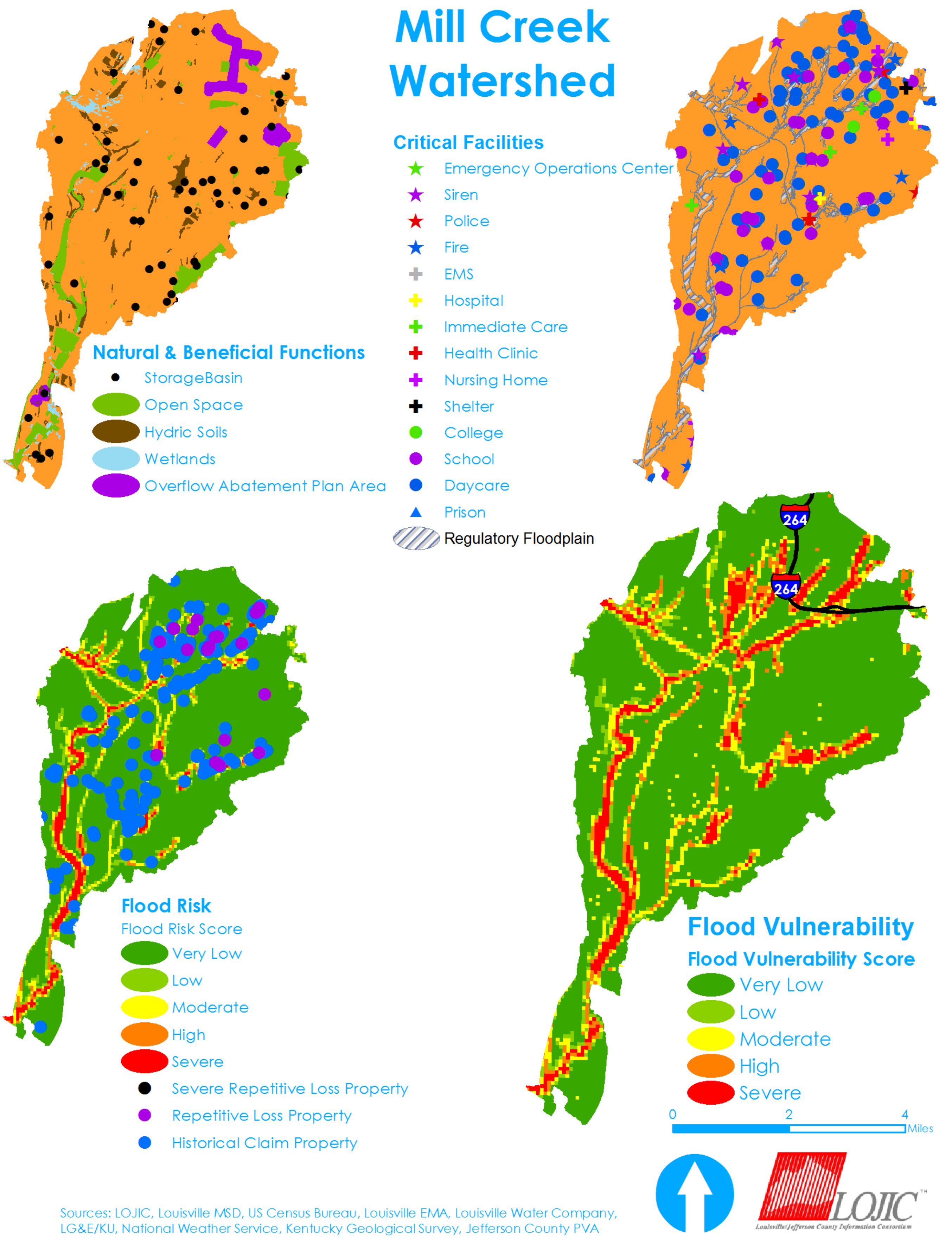
Velocities:

- Using the FIS Flood Profile data (Floodway) for Upper Mill Creek the mean average velocity is 4.8 feet per second. This data was derived from 10 cross sections on the Upper Mill Creek.
- Using the FIS Flood Profile data (Floodway) for Big Run Creek the mean average velocity is 5.1 feet per second. This data was derived from 8 cross sections on the Big Run Creek.
- Using the FIS Flood Profile data (Floodway) for Cane Run Ditch the mean average velocity is 1.7 feet per second. This data was derived from 6 cross sections on the Cane Run Ditch.
- Using the FIS Flood Profile data (Floodway) for Black Pond Creek the mean average velocity is 2.8 feet per second. This data was derived from 9 cross sections on the Black Pond Creek.

Note: The above information is a mean average for the flooding source. Specific locations will provide different outputs throughout the watershed. It should be noted that we can calculate a depth at any point within the floodplain by comparing the ground elevation from the digital terrain model to the flood elevation layer where data permits.

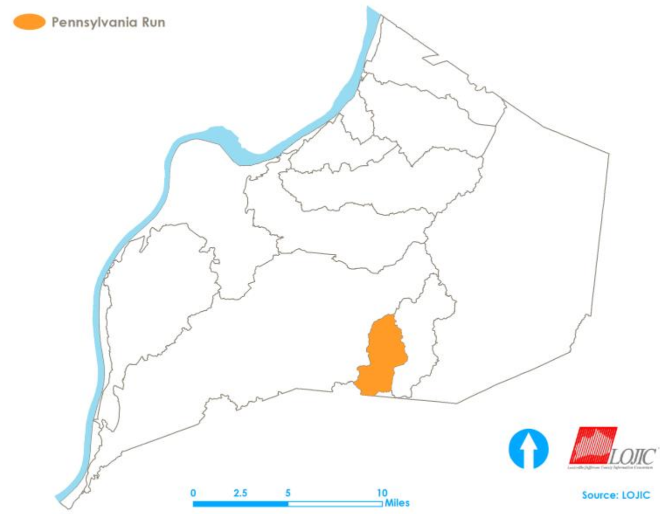
Figure 28 depicts the Mill Creek Watershed Vulnerability Score. This map details areas of high vulnerability based on several different factors such as: Regulatory Floodplain, Combined Sewer Floodprone Areas, Repetitive Loss Properties, Severe Repetitive Loss, and Historical Claims data. These variables provide a detailed Risk Score that displays areas at risk based on mapped floodplains and mapped occurrence hotspots. These two factors provide Louisville Metro with a comprehensive understanding of where flooding is occurring and potentially causing damage. In addition, Figure 28 displays critical facilities and the natural and beneficial functions for open space and wetlands locations. It is important to note that these maps are for display purposes, to truly use this data one would want to import this data into a GIS program.

Figure 28. Mill Creek Watershed



Mill Creek Watershed
Natural & Beneficial Functions
StorageBasin
Open Space
Hydric Soils
Wetlands
Overflow Abatement Plan Area
Critical Facilities
Emergency Operations Center
Siren
Police
Fire
EMS
Hospital
Immediate Care
Health Clinic
Nursing Home
Shelter
College
School
Daycare
Prison
Regulatory Floodplain
Flood Risk
Flood Risk Score
Very Low
Low
Moderate
High
Severe
Severe Repetitive Loss Property
Repetitive Loss Property
Historical Claim Property
264
264
Flood Vulnerability
Flood Vulnerability Score
Very Low
Low
Moderate
High
Severe
0
2
4
Miles
Sources: LOJIC, Louisville MSD, US Census Bureau, Louisville EMA, Louisville Water Company, LG&E/KU, National Weather Service, Kentucky Geological Survey, Jefferson County PVA
LOJIC

4.16.6.10. Pennsylvania Run Watershed



The seven square mile Pennsylvania Run Watershed is located in south central Louisville Metro and contains 33.4 stream miles, most of which are intermittent and ephemeral streams, with the exception of McNeeley Lake, a small recreational reservoir. Its headwaters originate in the Highview area, and the stream flows in a southerly direction, passing into Bullitt County, and eventually discharging into Cedar Creek. Pennsylvania Run is the only major stream in this watershed.

Pennsylvania Run originates from McNeely Lake and flows south. It merges with Cedar Creek in Louisville Metro, which eventually flows into Goose Creek downstream of Goose Creek at Bardstown Road.
Notable landmarks include McNeely Lake and McNeely Lake Park. McNeely Lake Park is located along Pennsylvania Run and provides preserved open space.

Topography
The entire Pennsylvania Run Watershed is situated in the Eastern Uplands Topographic Region. Broad, fairly steep-sided valleys and narrow ridge crests dominate the terrain. Streams have cut deeply into this terrain and flow through well-entrenched channels. Elevations vary from about 515 feet at the Jefferson County/Bullitt County line, to about 685 feet in the Highview area.

Existing Structural Flood Controls
No regional basins or major channel improvement projects are located in the Pennsylvania Run Watershed.

Basic Watershed Flood Information
Depth of Water: Using the FIS Flood Profile data for Pennsylvania Run the mean average depth of flooding from the stream bed to the Regulatory Floodplain is 6.3 feet. This data was derived from 52 cross sections on Pennsylvania Run.

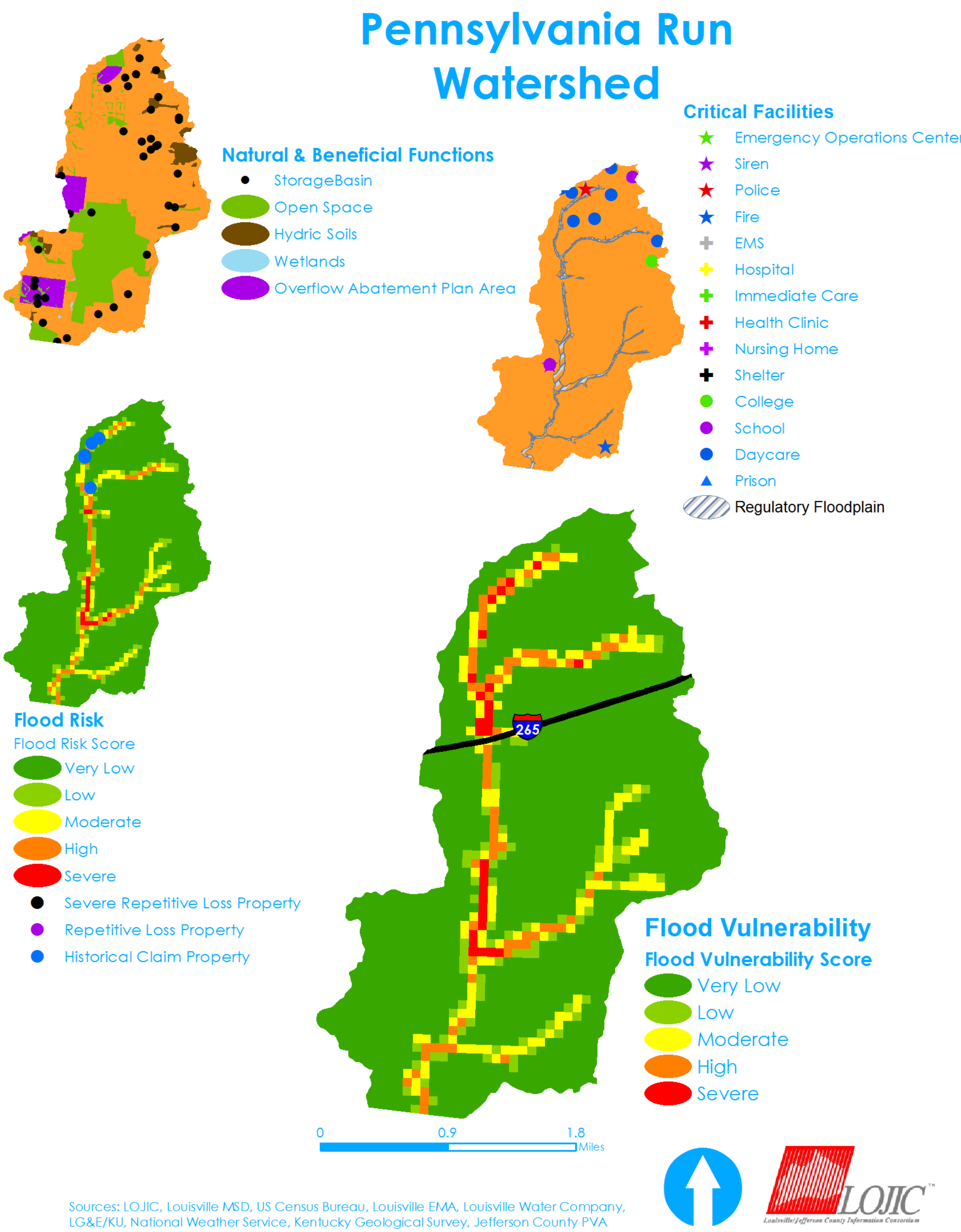
Velocities: Using the FIS Flood Profile data (Floodway) for Pennsylvania Run the mean average velocity is 4.9 feet per second. This data was derived from 52 cross sections on the Pennsylvania Run.

Note: The above information is a mean average for the flooding source. Specific locations will provide different outputs throughout the watershed. It should be noted that we can calculate a depth at any point within the floodplain by comparing the ground elevation from the digital terrain model to the flood elevation layer where data permits.

Figure 29 depicts the Pennsylvania Run Watershed Vulnerability Score. This map details areas of high vulnerability based on several different factors such as: Regulatory Floodplain, Combined Sewer Floodprone Areas, Repetitive Loss Properties, Severe Repetitive Loss, and Historical Claims data. These variables provide a detailed Risk Score that displays areas at risk based on mapped floodplains and mapped occurrence hotspots. These two factors provide Louisville Metro with a comprehensive understanding of where flooding is occurring and potentially causing damage.

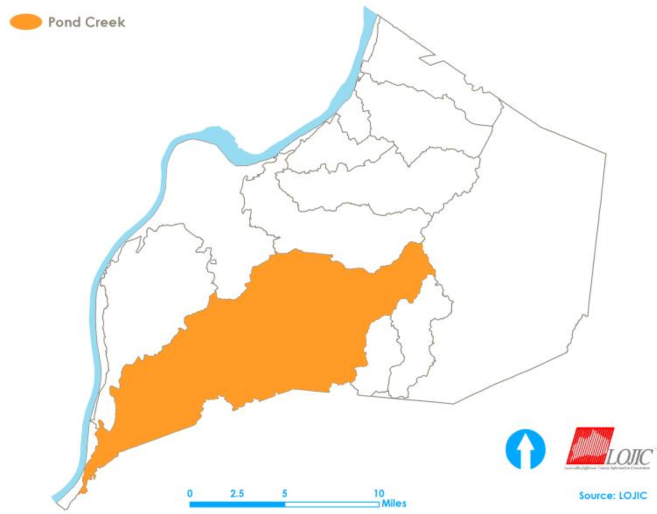
In addition, Figure 29 displays critical facilities and the natural and beneficial functions for open space and wetlands locations. It is important to note that these maps are for display purposes, to truly use this data one would want to import this data into a GIS program.

Figure 29. Pennsylvania Run Watershed



4.16.6.11. Pond Creek Watershed

The 94 square mile Pond Creek Watershed is located in south central and southwest Louisville Metro and contains 649.6 stream miles in Louisville Metro. It is primarily drained by a series of natural and improved channels called Fern Creek, Northern Ditch, Southern Ditch, and Pond Creek. The headwaters of Fern Creek originate in the west side of Jeffersontown and flow southwest to Shepherdsville Road. At this point, the flow turns to the west and the improved channel is called Northern Ditch. This westerly flow continues into the vicinity of the Louisville and Nashville Railroad's Osborn Yard, where it turns southwest and finally outlets into Southern Ditch at the Outer Loop. The flow in Southern Ditch, an improved channel, originates in the Smyrna area and moves west, generally paralleling the Outer Loop. From this point, Southern Ditch flows to the west about three-quarters of a mile, then turns to the southwest and flows about one mile to Manslick Road. Downstream from Manslick Road, the natural channel is called Pond Creek. It flows in a generally southwesterly direction to its eventual outlet into the Salt River. Numerous tributaries enter these four main channels, including Fishpool Creek, Mud Creek, Wilson Creek, Bee Lick Creek, Greasy Ditch, Duck Spring Branch, Salt Block Creek, Slate Run, Bearcamp Run, Crane Run, Brier Run, and Weaver Run.



Once a backwater slough for the Ohio River floodplain with shallow lakes and swampy forests called "wetwoods," the hydrology of the central and lower reaches of this watershed have been completely modified over the past two centuries. Upstream subwatersheds in the Pond Creek watershed include Fern Creek, Fishpool Creek, Mud Creek and Wilson's Creek. Bee Lick, Manslick, Slop Ditch (now Wetwoods Creek), Greasy Ditch, Blue Spring Ditch, Duck Spring Branch and other channelized drainage ditches also feed into the central drainage canals called Northern Ditch and Southern Ditch.

Brier Creek along the southern border of the county is in a rural valley in the Knobs, below Jefferson Forest. Brier Creek originates in Metz Gap and Jefferson Hill close to the Jefferson County Memorial Forest and flows west before merging into Pond Creek. Brier Creek is described as an independent watershed from Pond Creek.

Communities situated in this watershed include parts of Jeffersontown, Fern Creek, Highview, Newburg, Smyrna, Okolona, Lynnview, Auburndale, Fairdale, Prairie Village, Medora, Orell, and part of Valley Station. Notable landmarks include the Louisville International Airport, General Electric's Appliance Park, Ford Louisville Assembly Plant, Jefferson Mall, part of Iroquois Park, Komosdale Cement Plant, and much of the Jefferson County Memorial Forest. Three USGS gauges are located in the Pond Creek Watershed, including two on Pond Creek and one on Northern Ditch. Roberson Run Park is located along Roberson Run, a tributary of Pond Creek, and provides preserved open space along that tributary.

Topography

The Pond Creek Watershed is unique, in that it encompasses parts of all four of Louisville Metro's Topographic Regions. Fern Creek is in the Eastern Uplands. Northern and Southern Ditch are in the

Central Basin. Pond Creek has eroded a trench through the knobs and drains a portion of the Flood Plain.

In the Eastern Uplands Topographic Region, broad steep-sided valleys and gently rolling plateaus dominate the terrain. Major streams have cut deeply into this terrain and they flow through well-entrenched channels.

In the Central Basin Topographic Region, an extremely flat, low-lying terrain predominates. This was formerly a swampy area. The major streams have been greatly improved and flow in well entrenched, though very low gradient slope, channels.

In the Knobs Topographic Region, steep-sided, round-topped hills dominate the terrain. Stream channels are deeply cut into these hills and commonly have high gradient slopes.

In the Flood Plain Topographic Region, a very flat, low-lying terrain predominates. Stream channels of low gradient slopes tend to parallel the Ohio River, and terraces of ten to twenty feet in height are common.

Elevations range from about 382, the pool stage of the Ohio River below the McAlpine Lock and Dam, to in excess of 900 feet, along the county's southern boundary.

Existing Structural Flood Controls

The first regional basin built by MSD was the Roberson Run Basin. It was built in the early 1990s and is relatively small. Although the impacts on flooding are minimal by today's standards, the basin is a multiuse facility with the incorporation of walking paths around the basin that link adjoining residential areas.

In 1998, MSD, Jefferson County Government, and the U.S. Army Corps of Engineers began the construction phase of the Pond Creek Flood Prevention Project. The final phase of this project is currently underway.

The project will utilize large basins for flood storage and channel improvements to remove an estimated 2,000 buildings from the danger of most floods. In addition, the project will incorporate Greenways principles that will provide pedestrian access to Pond Creek. Walking and biking paths will help connect neighborhoods and introduce area residents to ever improving water quality along Pond Creek. A description of each phase of the project is listed below.

- Phase I: The Okolona Wetlands Restoration Site is an environmental restoration of 15 acres of wetlands located in a former sludge lagoon at the former Okolona Wastewater Treatment Plant. The restoration process included draining the area of sludge and replanting native vegetation. The plans for this restoration phase have been completed.
- Phase II: The Vulcan Detention Basin included constructing a dam on Fishpool Creek, installing a low-flow pipe, and constructing an overflow structure into the basin which was a limestone quarry. The basin was designed to fill during a 24-hour storm event and drain over a period of approximately eight days. This basin became operational in September 1999. The capacity of the detention basin is 450 acre-feet. A diversion dam was constructed across the creek and an 18'' pipe was placed through the dam to maintain base flows.
- Phase III: The Melco Detention Basin behind the Ford Motor Plant was completed in 2001. It expanded an existing 15-acre borrow pit to 80 acres, which increased the storage capacity to 1,500 acre-feet.

- Phase IV: This phase included channel modifications to Northern Ditch between Preston Highway and the Melco Basin inlet. It also included widening one bank of Northern Ditch for a distance of almost 1.5 miles, replacing culverts, and installing riffle structures and pools in the stream to improve aquatic habitat.
- Phase V: Channel modifications to Pond Creek and the placement of a multipurpose recreation trail alongside the creek are currently under construction. This phase includes widening one bank of Pond Creek for a distance of 2.4 miles, replacing culverts, and installing riffle structures and pools in the stream to improve aquatic habitat.

In addition to the Army Corps of Engineers project, MSD has also worked with a private company to create a floodplain and runoff compensation bank located in the Pond Creek Watershed. This compensation bank is funded through private development. It consists of three basins. Ponds 1 and 2 have been constructed. Pond 1 is located near I-65 and the Outer Loop and is 80 ac-ft. Pond 2 is located near Wilson Creek and the Gene Snyder Freeway and is 26.5 ac-ft. Pond 3 is currently under construction. This pond is located at National Turnpike and Southern Ditch and will be 234 ac-ft

Basic Watershed Flood Information

Depth of Water:

- Using the FIS Flood Profile data for Pond Creek the mean average depth of flooding from the stream bed to the Regulatory Floodplain is 16.3 feet. This data was derived from 10 cross sections on Pond Creek.
- Using the FIS Flood Profile data for Northern Ditch the mean average depth of flooding from the stream bed to the Regulatory Floodplain is 16.0 feet. This data was derived from 13 cross sections on Northern Ditch.
- Using the FIS Flood Profile data for Southern Ditch the mean average depth of flooding from the stream bed to the Regulatory Floodplain is 9.0 feet. This data was derived from 42 cross sections on Southern Ditch.
- Using the FIS Flood Profile data for Fern Creek the mean average depth of flooding from the stream bed to the Regulatory Floodplain is 12.8 feet. This data was derived from 5 cross sections on Fern Creek.

Velocities:

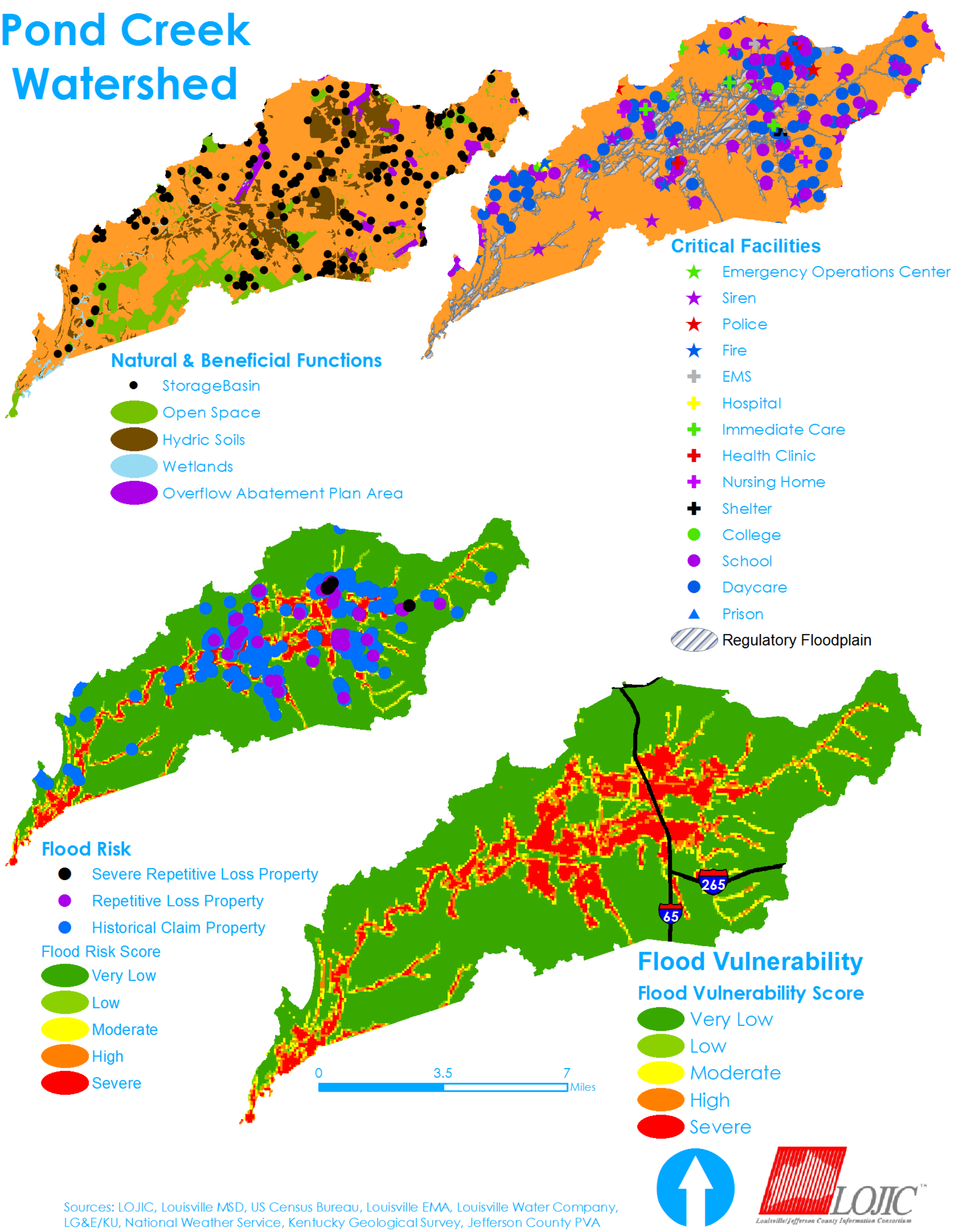
- Using the FIS Flood Profile data (Floodway) for Pond Creek the mean average velocity is 4.8 feet per second. This data was derived from 10 cross sections on the Pond Creek.
- Using the FIS Flood Profile data (Floodway) for Northern Ditch the mean average velocity is 3.7 feet per second. This data was derived from 13 cross sections on the Northern Ditch.
- Using the FIS Flood Profile data (Floodway) for Southern Ditch the mean average velocity is 5.0 feet per second. This data was derived from 42 cross sections on the Southern Ditch.
- Using the FIS Flood Profile data (Floodway) for Fern Creek the mean average velocity is 4.3 feet per second. This data was derived from 5 cross sections on the Fern Creek.

Note: The above information is a mean average for the flooding source. Specific locations will provide different outputs throughout the watershed. It should be noted that we can calculate a depth at any point within the floodplain by comparing the ground elevation from the digital terrain model to the flood elevation layer where data permits.

Figure 30 depicts the Pond Creek Watershed Vulnerability Score. This map details areas of high vulnerability based on several different factors such as: Regulatory Floodplain, Combined Sewer Floodprone Areas, Repetitive Loss Properties, Severe Repetitive Loss, and Historical Claims data.

These variables provide a detailed Risk Score that displays areas at risk based on mapped floodplains and mapped occurrence hotspots. These two factors provide Louisville Metro with a comprehensive understanding of where flooding is occurring and potentially causing damage. In addition, Figure 30 displays critical facilities and the natural and beneficial functions for open space and wetlands locations. It is important to note that these maps are for display purposes, to truly use this data one would want to import this data into a GIS program.

Figure 30. Pond Creek Watershed


Pond Creek Watershed
Critical Facilities
Emergency Operations Center
Siren
Police
Fire
EMS
Hospital
Immediate Care
Health Clinic
Nursing Home
Shelter
College
School
Daycare
Prison
Regulatory Floodplain
Natural & Beneficial Functions
StorageBasin
Open Space
Hydric Soils
Wetlands
Overflow Abatement Plan Area
Flood Risk
Severe Repetitive Loss Property
Repetitive Loss Property
Historical Claim Property
Flood Risk Score
Very Low
Low
Moderate
High
Severe
265
65
Flood Vulnerability
Flood Vulnerability Score
Very Low
Low
Moderate
High
Severe
0
3.5
7
Miles
Sources: LOJIC, Louisville MSD, US Census Bureau, Louisville EMA, Louisville Water Company, LG&E/KU, National Weather Service, Kentucky Geological Survey, Jefferson County PVA
LOJIC
Louisville/Jefferson County Information Consortium

4.16.6.12. Basic Watershed Flood Information

The following table combines all of the watersheds "Basic Watershed Flood Information".

Table 19. Basic Watershed Information

Watershed	Flooding Source	Average Depth of Water	Average Velocities
Ohio River/City	Ohio River	80	4.9
Middle Fork Beargrass Creek	Middle Fork Beargrass Creek	13.2	4.9
	Weicher Creek	5.4	3.8
Muddy Fork Beargrass Creek	No data	No Data	No data
South Fork Beargrass Creek	South Fork Beargrass Creek	14.6	5
	Buechel Branch	9.9	3.4
Cedar Creek	Cedar Creek	23.5	No data
Floyds Fork	Floyds Fork	22.3	4.9
Goose Creek	Goose Creek	4.9	4.7
Harrods Creek	Harrods Creek	41	7.3
	South Fork Hite Creek	8.2	4
Mill Creek	Upper Mill Creek	16.3	4.8
	Big Run Creek	9.6	5.1
	Cane Run Ditch	10	1.7
	Black Pond Creek	11.7	2.8
Pennsylvania Run	Pennsylvania Run	6.3	4.9
Pond Creek	Pond Creek	16.3	4.8
	Northern Ditch	16	3.7
	Southern Ditch	9	5
	Fern Creek	12.8	4.3

Note: The Average Depth of Water was calculated from the stream bed to the Regulatory Floodplain based on the 2006 Louisville and Jefferson County Kentucky FIS. The Average Velocities were calculated from the same report.

5. Mitigation Strategy

44 CFR Part 201
Mitigation Planning

§201.6(c)3

The plan shall include a mitigation strategy that provides the jurisdiction's blueprint for reducing the potential losses identified in the risk assessment, based on existing authorities, policies, programs and resources, and its ability to expand on and improve these existing tools.

The Local Mitigation Plan requirements encourage agencies at all levels, local residents, businesses, and the nonprofit sector to participate in the mitigation planning and implementation process. This broad public participation enables the development of mitigation actions that are supported by these various stakeholders and reflect the needs of the community.

The Mitigation Action Plan responds to the Risk Assessment with projects and activities to mitigate Louisville's natural and man-made hazards. The action plan outlines projects in a five-year plan that allows Louisville Metro to make informed future land use and zoning decisions, design better infrastructure, and keep the public out of harm's way.

Moreover, the updated Plan and Mitigation Strategy provides a proactive, community mitigation program of activities, projects and programs that will help local agencies, residents, and businesses to be better prepared to prevent and/or reduce losses from an identified hazard. Louisville Metro has been very successful to-date with mitigation activities, including regulatory and legislation actions.

The Mitigation Strategy is specific to exposure and impacts by each hazard and lists prioritized hazard mitigation projects that best meet Louisville's needs for multiple hazard damage reduction. Section 4 outlines the design of the Mitigation Strategy developed through a tier of meetings and coordination with our stakeholder group. The mitigation strategy is based upon the best available data and provides a blueprint for reducing the potential losses identified in the risk assessments which are the factual basis for the mitigation strategy.

The section reviews the problems and common issues in Louisville Metro and details how the Advisory Committee revised the community's goals and objectives by utilizing a multi-hazard approach. The Louisville Metro's Capability Assessment outlines state and local ordinances, statues and regulations, and reviews funding mechanisms. Ongoing programs are outlined in the section which assisted the Advisory Committee to develop a five-year Action Plan.

5.1. State Capability Assessment

To set the stage for a mitigation strategy it is imperative to know the capability of the community to perform mitigation, regulate, and design outreach. Reducing hazards is a priority for Louisville Metro and the Commonwealth of Kentucky. State regulations affect all of Kentucky and each local community is subject to them. However, a community may adopt laws that are even more restrictive.

The following subsections outline hazard mitigation activities listed in the 2010 State Hazard Mitigation Plan that evaluates state regulations, policies, and state-funded or administered programs. Following this description of State capabilities there is a similar section/description of Louisville Metro's capabilities. The intent in listing both the State and Local capabilities is to develop a better understanding of state government activities related to hazard mitigation and their impact on local communities. In addition, an analysis of the regulatory functions with respect to mitigation and hazards planning is imperative to good planning.

Among the best examples of hazard mitigation in State government are the floodplain management program, the dam safety program, and the FEMA-funded State administered hazard mitigation programs. However, a number of other programs, funding sources, executive orders, and interagency agreements have elements that can support or facilitate hazard mitigation. The state's capability is the foundation of similar capabilities by local government. As mentioned, following this section is a detailed discussion of Louisville Metro's capability, regulations, and ordinances.

The following section provides a synopsis of the State Regulatory Analysis. The expanded State Hazard Mitigation Capability Matrix can be found in Appendix 4.1.

5.1.1.State Regulatory Analysis and Funding Summary

5.1.1.1. Kentucky Pre- and Post- Disaster Legislation

The Kentucky General Assembly realizes that the Commonwealth is subject to disasters or emergency occurrences at all times. These instances can range from events affecting limited areas to widespread catastrophic events. Immediate and effective response to these occurrences is a fundamental responsibility of elected government. Therefore, the General Assembly established a statewide comprehensive emergency management system to provide assessment and mitigation of threats to public safety and the negative externalities resulting from all major hazards.

The Kentucky Revised Statutes (KRS) were enacted in 1942 to eliminate provisions no longer in force or effect and to compile the remaining laws into a comprehensible form. In July of 1998, KRS 39A.010 established the Kentucky Division of Emergency Management (KyEM) and local emergency management agencies, replacing Kentucky Disaster and Emergency Services. In addition, the emergency powers provided in KRS Chapter 39A through 39F were conferred upon the Governor, the county judges/executives, the mayors of cities and urban-county governments, and the chief executives of local governments. Provisions were also established for mutual aid among the cities, counties, and urban-county governments of the Commonwealth.

There are a number of sections in KRS which address the issues of emergency systems, hazard safety, and hazard mitigation. There are several statutes which specifically pertain to pre-disaster mitigation:

KRS 39 - The KyEM shall coordinate for the Governor all matters pertaining to the comprehensive emergency management program and disaster and emergency response of the Commonwealth. The division shall be the executive branch agency of state government having primary jurisdiction, responsibility, and authority for the planning and execution of disaster and emergency assessment, mitigation, preparedness, response, and recovery for the Commonwealth (KRS 39A.050).

KRS 147 - Any general fund appropriations made for the Local Match Participation Program may be used for flood control planning and mitigation activities and straight sewage pipe removal and mitigation activities (KRS 147A.029).

KRS 149 - There are two official fire hazard seasons as established by the state legislature (KRS. 149.400). The fire seasons run from February 15 - April 30 and October 1- December 15. During the official fire seasons, "it shall be unlawful for any person to set fire to, or procure another to set fire to any flammable material capable of spreading fire, located in or within one hundred fifty (150') of any woodland or brushland, except between the hours of 6:00 p.m. and 6:00 a.m., prevailing local time, or when the ground is covered with snow". Open burning requirements are outlined in 401 KAR 63:005.

KRS 151 - The Energy and Environment Cabinet shall administer KRS 151 and establish the requirements for obtaining a floodplain development permit (KRS 151.250). The water resources authority shall develop a public information program for use by local units of government which will assist them in the development of floodplain management and flood hazard mitigation programs (KRS 151.600).

KRS 158 - The board of each local school district, and the governing body of each private and parochial school or school district, shall establish an earthquake and tornado emergency procedure system in every public or private school building in its jurisdiction having a capacity of 50 or more students, or having more than one classroom (KRS 158.163). The earthquake and tornado emergency procedure system shall include, but not be limited to:

- A school building disaster plan, ready for implementation at any time, for maintaining the safety and care of students and staffs;
- A drop procedure - an activity by which each student and staff member takes cover under a table or desk, dropping to his or her knees, with the head protected by the arms, and the back to the windows;
- A safe area - a designated space including an enclosed area with no windows, a basement or the lowest floor using the interior hallway or rooms, or taking shelter under sturdy furniture;
- Protective measures to be taken before, during, and following an earthquake or tornado;
- A program to ensure the students and the certificated and classified staff are aware of and properly trained in, the earthquake and tornado emergency procedure system.

KRS 198B - The Uniform State Building Code (KRS 198B.050) addresses issues concerning seismic and severe wind construction in response to the Commonwealth's potential earthquake and wind threats.

KRS 211 - The Cabinet for Health Services shall develop and conduct programs for evaluation and control of activities related to radon including laboratory analyses, mitigation, and measurements (KRS 211.855).

In addition to KRS legislation, the following are other initiatives which address state hazard mitigation:

Jurisdictions which participate in the NFIP have established ordinances related to floodplain development. In addition, as a NFIP community, when purchasing a home located within the boundary of a special flood hazard area (SFHA), the buyer is required to purchase flood insurance.

Kentucky Drought Mitigation and Response Plan: Prepared by the Energy and Environment Cabinet in partnership with the Kentucky Drought Mitigation and Response Advisory Council. In fulfillment of the directive of Senate Joint Resolution 109, December 31, 2008; this plan provides statewide guidance to assess and minimize the impacts of a drought in Kentucky. This plan serves as a foundation to a proactive drought planning process intended to reduce drought risk in Kentucky. The plan describes a simple collaborative approach to accelerate the decision-making processes of state and federal agencies that are necessary to assist local government efforts in drought response. It establishes a mechanism for these agencies to work together during non-drought years with various agencies and individuals outside of state government to identify mitigation actions that can be taken to reduce the impacts of future droughts.

Flood Map Modernization in Kentucky: Map Modernization is a cornerstone for helping communities to be better prepared for flood disasters. The NFIP currently serves 4.5 million policyholders and provides $650 billion in coverage nationwide. Kentucky is in the process of updating flood maps statewide with the goal of identifying flood hazards for areas that drain more than 1 square mile (640 acres). It is important to remember that every stream, large or small, has a floodplain and that any downstream structure may be damaged during flooding. The new aerial-photo-base maps will show areas that are likely to be flooded during a 1-percent-annual-chance flood. To accomplish map modernization, KDOW has formed partnerships with the Kentucky Transportation Cabinet (KYTC), Kentucky Division of Geographic Information, Kentucky Division of Emergency Management (KyEM), U.S. Geological Survey (USGS), Kentucky Council of Area Development Districts (ADDs), and U.S. Army Corps of Engineers (USACE). The end product of these partnerships will be not only digital floodplain maps, but also information that can be used for homeland security, natural resource conservation, emergency management, and transportation purposes in order to promote economic development and maximize mitigation efforts.

The following table analyzes the tools available at this time in the Commonwealth. The table depicts the existing authorities, policies, programs and resources, and how they affect the hazard mitigation process.

State And Local Capabilities Assessment	
Existing Authorities	Floodplain Management Ordinance
	Building Codes
	Zoning Regulations
	Subdivision Regulations
	Fire Prevention Codes (State)
	Stormwater Management Plans
	Hazardous-Materials Ordinance
Programs	NWS Storm Ready Program
	Emergency Operations Plan
	Community Rating System
	Flood Map Modernization
Resources	Local Economic Developments
	Regional Development Agency
	Local Emergency Management Agency
	Local Emergency Planning Committee
	Kentucky Drought Mitigation and Response Plan

5.1.1.2. Federal Funding and Technical Assistance Sources

Various federal government agencies offer a wide range of funding and technical assistance programs to help with mitigation efforts. The table below is a list of FEMA Funding and Technical Assistance programs available to states and local communities.

FEMA-Funded Hazard Mitigation Assistance Grant Programs		
Grant Name	**Purpose**	**Hazard Mitigation Application**
Flood Mitigation Assistance (FMA)	To help States and communities plan and carry out activities designed to reduce the risk of flood damage to structures insurable under the NFIP.	The program provides planning, project and technical assistance grants for mitigation activities that are technically feasible and cost effective.
Hazard Mitigation Grant Program (HMGP)	To prevent future losses of lives and property due to disasters; to implement State or local hazard mitigation plans; to enable mitigation measures to be implemented during immediate recovery from a disaster; and to provide funding for previously identified mitigation measures to benefit the disaster area.	Project grants can be funded for such activities as acquisition, relocation, elevation, and improvements to facilities and properties to withstand future disasters.
Pre-Disaster Mitigation (PDM)	The PDM program provides funds to states, territories, Indian tribal governments, communities, and universities for hazard mitigation planning and the implementation of mitigation projects prior to a disaster event. Funding these plans and projects reduces overall risks to the population and structures, while also reducing reliance on funding from actual disaster declarations.	Provides funds for hazard mitigation planning and the implementation of mitigation projects prior to a disaster event.

5.1.1.3. Legal Authority of Counties and Cities in Kentucky

Local governments in Kentucky have a wide range of tools available to them for implementing mitigation programs, policies and actions. A hazard mitigation program can utilize any or all of the four broad types of government powers granted by the State of Kentucky, which are (a) Regulation; (b) Acquisition; (c) Taxation; and (d) Spending. Following is a summary of the four broad types.

Regulation

General Police Power
Local governments have been granted broad regulatory powers in their jurisdictions. Kentucky Revised Statutes assign general police power to local governments, allowing them to enact and enforce ordinances that define, prohibit, regulate or abate acts, omissions, or conditions detrimental to the health, safety, and welfare of the people, and to define and abate nuisances (including public health nuisances).

Since hazard mitigation can be included under the police power (as protection of public health, safety and welfare), towns, cities and counties may include requirements for hazard mitigation in local ordinances. Local governments may also use their ordinance-making power to abate "nuisances," which could include, by local definition, any activity or condition that threatens the general health and safety of the public.

Louisville Metro has enacted and enforces regulatory ordinances designed to promote the public health, safety, and general welfare of its citizenry.

Building Codes and Building Inspection
Many structural mitigation measures involve constructing and retrofitting homes, businesses, and other structures according to standards designed to make the buildings more resilient to the impacts of natural hazards. Many of these standards are imposed through the use of building codes. Jurisdictions have the opportunity and the power to develop and enforce building codes. Louisville Metro has adopted and enforces a building code, which will be discussed in detail in a later section.

Land Use
Regulatory powers granted by the state to local governments are the most basic manner in which a local government can control the use of its land. Through various land use regulatory powers, a local government can control the amount, timing, density, quality, and location of new development. All these characteristics of growth can determine the level of vulnerability of the community in the event of a natural hazard. Land use regulatory powers include the power to engage in planning, enact, and enforce zoning ordinances, floodplain ordinances, and subdivision controls. Louisville Metro has adopted Cornerstone 2020, the community's comprehensive plan, and the Land Development Code (LDC) that govern land use decisions. Both are discussed in more detail in the next subsection.

Planning
Local jurisdictions have the authority to perform a number of duties related to planning, including: make studies of the area; determine objectives; prepare and adopt plans for achieving those objectives; develop and recommend policies, ordinances, and administrative means to implement plans. The Louisville Metro Planning Commission oversees planning activities. The Louisville Metro Department of Planning and Design Services (PDS) is responsible for overseeing development activities and advises the Planning Commission.

Zoning
Zoning is the traditional and most common tool available to local governments to control the use of land. The statutory purpose for the grant of power is to promote health, safety, morals, or the general welfare of the community. Land "uses" controlled by zoning include the type of use (e.g., residential, commercial, industrial) as well as minimum specifications for use such as lot size, building height and set backs, density of population, etc. The Louisville Metro Development Code is the basis for all zoning decisions in the Metro Area. The Planning and Design Services staff is responsible for review of all zoning cases within Louisville Metro and the Planning Commission makes recommendations on whether or not they should be approved. The Louisville Metro Council is ultimately responsible for approval of all zoning requests except for zoning cases located within the boundaries of cities of the 4th Class and higher. In these cities, the appropriate city council makes the final decision. These cities are: Anchorage, Douglass Hills, Greymoor-Devondale, Hurstbourne, Indian Hills, Jeffersontown, Lyndon, Middletown, Prospect, St. Matthews, St. Regis Park and Shively.

Subdivision Regulations
Subdivision regulations control the division of land into parcels for the purpose of building development or sale. Flood-related subdivision controls typically require that subdividers install adequate drainage facilities and design water and sewer systems to minimize flood damage and contamination. They prohibit the subdivision of land subject to flooding unless flood hazards are overcome through filling or other measures, and they prohibit filling of floodway areas. Subdivision regulations require that subdivision plans be approved prior to the division/sale of

land. Subdivision regulations are a more limited tool than zoning and only indirectly affect the type of use made of land or minimum specifications for structures. The Louisville Metro Subdivision Regulations are included in the LDC and discussed in more detail in the next subsection.

Floodplain Ordinance
The purpose of the local floodplain ordinance is to (1) minimize the extent of floods by preventing obstructions that inhibit water flow and increase flood height and damage; (2) prevent and minimize loss of life, injuries, property damage and other losses in flood hazard areas; and (3) promote the public health, safety and welfare of citizens of the jurisdiction in flood hazard areas. The ordinance also makes certain that the community meets the minimum requirements for participation in the NFIP.

The incentive for local governments adopting such ordinances is that they will afford their residents the ability to purchase flood insurance through the NFIP and be eligible for state Hazard Mitigation funding. Floodplain regulations were adopted in Louisville Metro and are included in the LDC and discussed in more detail in the next subsection.

Louisville Metro is a participant in FEMA's Community Rating System (CRS), which rewards communities that implement projects to mitigate the impacts of flooding with reductions in flood insurance rates. Louisville Metro is currently rated as Class 3, which puts it in the top 7 of communities nationwide. Class 3 results in a 35% reduction in flood insurance rates for homeowners in the floodplain.

Hazardous Materials Ordinance
The purpose of the Louisville Metro Hazardous Materials Ordinance (HMO) is for the protection of public health and safety through the prevention and control of hazardous materials incidents and releases and requires the timely reporting of releases. It applies to all parties who manufacture, use or store hazardous materials in quantities prescribed by the ordinance. The ordinance will be discussed in more detail.

Acquisition
The power of acquisition can be a useful tool for pursuing local mitigation goals. For example, local governments may find the most effective method for completely "hazard-proofing" a particular piece of property or area is to acquire the property (either in fee or a lesser interest, such as an easement), thus removing the property from the private market and eliminating or reducing the possibility of inappropriate development occurring. The state of Kentucky legislation empowers cities, towns, counties, and other government entities, such as the MSD and Louisville Water Company to acquire property for public purpose.

Taxation
The power to levy taxes and special assessments is an important tool delegated to local governments by the State of Kentucky. The power of taxation extends beyond merely the collection of revenue, and can have a profound impact on the pattern of development in the community.

Local governments can also raise funds through the implementation of special fees. One fee in particular which has relevance to hazard mitigation is the Stormwater User Fee implemented by MSD in January 1987. This fee is charged to all property owners within the MSD Service Area and is based on the amount of impervious surface on developed property. The money generated by this fee (over $31.7 million in FY 2010) is used for flood protection, drainage maintenance, capital projects, and administration of the community's stormwater management program.

Spending

The fourth major power that has been delegated from the Kentucky General Assembly to local governments is the power to make expenditures in the public interest. Hazard mitigation principles can be made a routine part of all spending decisions made by the local government, including the adoption of annual budgets.

5.2. Louisville Metro Capability Assessment Overview

Most residents of Louisville Metro have a general knowledge about the potential hazards that their community faces. However, residents have had little education concerning mitigation actions that increase or decrease the communities' vulnerability to certain hazards. Education concerning mitigation strategies and potential losses are a key factor for Louisville Metro's mitigation strategy.

Because of the Louisville area's history with natural disasters in the past 10 years, it is expected that there is generalized support for advancing hazard mitigation strategies. Louisville Metro has attended and participated in the mitigation planning process, largely due to the fact that the community has been widely affected by these natural disasters.

Louisville's 2005 Action Plan recommended mitigation projects that could be implemented through existing programs and integrated into job descriptions, comprehensive plans, capital improvement plans, zoning and building codes, permitting, and other planning tools, where appropriate. Fortunately, many of the agencies who are implementing the Action Plan are members of the Advisory Committee. The 2016 Action Plan follows suit with incorporating existing planning mechanisms.

5.2.1. Incorporation into Existing Planning Mechanisms

The updated Plan includes documentation that existing plans, studies, reports, and technical information are reviewed and incorporated. The 2010 and 2013 Kentucky State Hazard Mitigation Plans were invaluable and were reviewed and incorporated, as appropriate. Project Staff also reviewed all materials and incorporated them into the updated Plan, as appropriate. Material includes existing mitigation activities, GIS data, studies, plans, ordinances, land use regulations, and any available technical information.

Project Staff requested agencies/organizations to review common problems, development policies, mitigation strategies, and inconsistencies and conflicts in policies, plans, programs, and regulations. Examples of existing local studies/plans include: information from USACE, CRS, NFIP, HMGP, development plans, floodplain management plan, comprehensive and capital improvement plans, watershed plans, EOC plans, transportation plans, and academic reports. Project Staff also talked to experts from federal, state, and local agencies and universities to ensure all available information was reviewed.

The following Code Summary chart shows the relationship between the local development regulations and the Louisville Metro identified hazards.

Louisville Metro Code Summary	Dam Failure	Drought	Earthquake	Extreme Heat	Flood	Hailstorms	HazMat	Karst/Sinkhole	Landslide	Severe Storm	Severe Winter Storm	Tornado	Wildfire
Cornerstone 2020	N	N	N	N	Y	N	Y	Y	Y	N	N	Y	Y
Land Development Code	N	N	N	N	Y	N	Y	Y^P	Y^P	N	N	Y	Y^P
Floodplain Management Ordinance	N	N	N	N	Y^P	N	Y	N	N	N	N	N	N
Building Code	N	N	Y^P	Y	Y	Y^P	N	Y	Y	Y^P	Y^P	Y^P	N
Residential Code	N	N	Y^P	Y	Y	Y^P	N	Y	Y	Y^P	Y^P	Y^P	N
Hazardous Materials Ordinance	N	N	N	N	N	N	Y^P	N	N	N	N	N	N

"**Y**" means that the regulation addresses at least partially the identified hazard
"**Y^P**" means that the regulation is the primary one for that hazard
"**N**" means that the regulation does not currently address the hazard

5.2.2. Louisville Metro Floodplain Regulations

NFIP Compliance
All Local Mitigation Plans approved by FEMA after October 1, 2008 must describe the jurisdiction's participation in the NFIP and must identify, analyze and prioritize actions related to continued compliance with the NFIP. Participation in the NFIP is based on an agreement between communities and FEMA. The NFIP has three basic aspects: 1) floodplain identification and mapping; 2) floodplain management; and 3) flood insurance.

NFIP participation requires community adoption of flood maps. Mapping flood hazards creates broad-based awareness of the flood hazards and provides the data needed to administer floodplain management programs and to actuarially rate new construction for flood insurance. To be a participant, the NFIP requires communities to adopt and enforce minimum floodplain management regulations that help mitigate the effects of flooding on new and improved structures. Community participation in the NFIP enables property owners to purchase insurance as a protection against flood losses in exchange for State and community floodplain management regulations that reduce future flood damages.

Louisville Metro's compliance NFIP actions include adoption and enforcement of floodplain management requirements, including regulating all new and substantially improved construction in Special Flood Hazard Areas (SFHAs) and floodplain identification and mapping, including any local requests for map updates.

Floodplain Management Ordinance
Louisville Metro area originally joined the NFIP in the late 1970s. FEMA identified five areas within Jefferson County and assigned Community IDs (CID) to: City of Jeffersontown, CID #210121 with a Post-FIRM date of 3/5/76 City of Louisville, CID #210122, 7/17/78 City of Shively, CID #210124, 8/1/78 City of St. Matthews, CID #210123, 3/5/76 Unincorporated Jefferson County, CID #210120, 4/16/79

In 2006, as part of the adoption of a new Flood Insurance Study (FIS), FEMA recognized the new Louisville Metro government structure and assigned one Community ID, 210120 to the entire Louisville Metro area.

The Post-FIRM (Flood Insurance Rate Map) date refers to when the community first adopted floodplain regulations and the FIRM's for that community. The Corps of Engineers developed the original floodplain maps for FEMA in the early 1970s and covered only the area within each of the jurisdictions. They were prepared using different map scales and were difficult to use particularly for properties located on or near the borders of the maps. The maps were updated in 1994 by the Corps in partnership with Jefferson County, LOJIC, and MSD utilizing the then new LOJIC mapping for the county and some new hydrologic and hydraulic models developed by MSD. The maps were the first approved by FEMA that were based on a local community's digital base maps. In December of 2006 revised maps for Louisville Metro developed by MSD under a grant from FEMA as part of the CTP program were approved and adopted.

The Floodplain Ordinance for Jefferson County was originally adopted in 1978 as Article 13 of the Development Code and basically met the minimum FEMA requirements (except it included a 1' freeboard requirement). The ordinance was also adopted by the four cities affected within the County. The Water Management Division of the County Public Works Department was designated as the review and approval agency for all development in the floodplain in the County (including the four cities). A separate floodplain permit was not issued at that time. Instead, Water Management approved plans and those plans became part of the building permit issued by the County or the City. Enforcement was done by the agency issuing the building permit in cooperation with Water Management. On January 1, 1987 MSD was designated the review and approval agency as part of the new stormwater management program implemented by MSD, the County and the City of Louisville. MSD continued enforcement using the process in place at that time.

The Floodplain Ordinance was revised in 1989 in order to meet new FEMA requirements and also to reflect MSD's new role in the enforcement process. The new ordinance exceeded the FEMA minimum in several areas including the 1' freeboard and a requirement to base the substantial damage/improvement calculations on the cumulative cost over the life of the structure. Jefferson County and the City of Louisville joined the CRS at that time. Based on the higher regulatory standards and other programs implemented Louisville Metro is a Class 3 CRS community. This provides a 35% discount for flood insurance for properties located within the 100-year floodplain.

On September 9, 1997 Jefferson County adopted Ordinance #23, Series 1997, Chapter 157 of the Jefferson County Code of Ordinances. The ordinance was the result of a community wide effort to strengthen the floodplain regulations as a result of the impact of past flooding events. In particular, the flood of March 1997 was fresh in the minds of the community when the ordinance was adopted. Besides strengthening the regulations in several important areas, the new ordinance created a floodplain permit process administered by MSD and a Floodplain Board (the MSD Board) to oversee the process. MSD staff now reviews all development plans in the floodplain, issues a specific floodplain permit and enforces the provisions of the ordinance. The Floodplain Board is responsible for enforcement and requests for appeals and variances. Appeals to the Floodplain Board's actions are to Jefferson County Circuit Court. Penalties for violation were also increased from the previous versions of the ordinance.

As part of the Floodplain Management Plan program, the local task force worked with MSD staff and the Jefferson County Attorney's office to revise the 1997 ordinance to reflect the merger of the City and County and also to implement several changes intended to enhance the enforcement process. The revised Louisville-Jefferson County Metro Government Floodplain Management ordinance (Ordinance No. 125, Series 2005) was adopted by the Metro Council in December 2006.

It should be noted that under the State Regulations, KAR 4:060, a separate state stream construction permit is also required for all development in the floodplain. Since the Louisville Metro ordinance is stricter than the state regulations, the local permit is enforced, but the state permit must also be obtained. MSD staff and the State Division of Water have implemented a process to speed up permit approvals.

5.2.3. Ongoing Programs

As the ongoing programs are monitored, updated, and evaluated, the mitigation strategy outlined in this Plan can be incorporated into these programs. As a result, a comprehensive mitigation strategy will better prepare Louisville Metro for all hazards. Example Louisville Metro's emergency and mitigation program activities listed below demonstrate the ongoing efforts to mitigate the effects of multi-hazards in Louisville Metro.

MSD and USACE Projects
MSD has a long, established history of a partnership with the Louisville District Army Corps of Engineers. MSD has worked with the Army Corps of Engineers on floodplain modeling, Flood Insurance Studies (FIS), greenway projects, flood storage programs, and wetlands banking programs. Following are samples of projects with the USACE:

Pond Creek Flood Protection Project
Project consists of two major sidesaddle detention basins, widening of Northern Ditch and Pond Creek and 15 acres of wetland mitigation.

South Fork Beargrass Creek Flood Protection Project
All construction is completed on the eight detention basins, channel widening near Newburg Road and the floodwall/levee at Willowbrook Apartments. The Operations and Maintenance (O&M) Manuals have been turned over to MSD.

Southwest Louisville Flood Protection Project
This project is evaluating the feasibility of constructing backflow prevention devices in affected homes or at the right-of-way to prevent flooding of basements in the combined sewer system area. Also studied was the feasibility of constructing major detention facilities in this same area to retain potential floodwaters. However, it was determined that the basins were not cost effective as stand-alone flood prevention alternatives.

Project alternatives now include only the use of backflow prevention devices in combination with detention facilities to offset the loss of floodplain storage within the basements. Part of the project will be to ascertain how more "voluntary" participation can be attained or if it will be made mandatory. As part of this voluntary participation, best management practices such as dry wells, rain barrels, and other low impact development alternatives will be studied to reduce direct runoff into the sewer systems. Eventually, this project will be funded as part of MSD's Wet Weather Consent Decree.

Upper Mill Creek Flood Protection Project

A Feasibility Study cost sharing agreement was completed in 2005. This study is evaluating possible flood control basins and channel improvements in the Upper Mill Creek watershed. If a feasible alternative is identified, MSD and the Corps will pursue a cost-sharing agreement for the remaining design and construction.

Cooperating Technical Partners Program (CTP)

FEMA's innovative CTP has the main objective of increasing local involvement in the flood mapping process. The CTP encourages collaboration with NFIP communities and regional and State agencies who wish to become more active participants in the FEMA flood hazard mapping program.

RiskMAP

As a CTP, the Louisville Metro 2011 RiskMAP project will include updating floodplain modeling for approximately 224 miles of streams within Jefferson County. Updated DFIRMs and an updated FIS will be produced and will replace the current effective DFIRMs and FIS. Wherever possible, existing approximate study areas will be replaced with detailed and limited detailed studies in order to have more accurate information available for the community. Preliminary maps are expected in the summer of 2012, with the final maps approved in the fall of 2013. Included in the RiskMAP requirements will be the certification of the Louisville Metro levee/floodwall system to protect against the 1% annual-chance flood.

Jefferson County Geodetic Control Network

LOJIC has established a local network of 273 first-order horizontal/vertical control monuments throughout Jefferson County. The local control network is annually maintained in order to verify existing control, reset disturbed monuments and further densify the control network.

To accomplish the goal of providing user-friendly public access to the geodetic control network databases, descriptions and photos, LOJIC developed an interactive web-based map using LOJIC GIS data and ESRI's ArcIMS software. It uses existing LOJIC orthoimagery as its base map along with street names and control monuments, which are displayed in the map view. Users can navigate and zoom into an area of interest by entering an address, street intersection, property parcel number or a specific control monument. A simple site map may also be created from the map view and an on-line help tool is always accessible.

Louisville Metro Snow Team

Louisville Metro Public Works, Solid Waste Management Services, Metro Parks, and MSD clear 1,362 miles of road in Louisville. The Commonwealth of Kentucky is responsible for clearing the interstates, expressways and highways. As part of an agreement with the Kentucky Transportation Cabinet (KYTC), Louisville crews now maintain most state roads and highways in Louisville. More brine routes have been added - from 700 miles to more than 900 miles, except for interstates. LOJIC and Metro Public Works have created an interactive snow routes map that allows citizens to enter their address to see the current information on the routes being cleared during a snow or ice event. The Snow Routes Map is available on LOJIC's website at: http://www.lojic.org/snow/viewer.htm.

Severe Storms and Earthquake Preparedness Program

Each year the State of Kentucky has two months set aside for local communities to participate in Severe Storms and Earthquake Preparedness activities. The Louisville Metro EMA compiles a calendar of events for both preparedness programs. Local activities include a comprehensive outreach program and a drill at one or more local and private schools caps off the month-long activities.

National Weather Service (NWS)

NWS has several programs in the Louisville Metro area. The NWS' website for Louisville is at: http://www.crh.noaa.gov/lmk/.

One-Hour Reporting Stream Gauges

The NWS placed all one-hour reporting Louisville Metro stream gauges on its Advanced Hydrologic Prediction Service webpage. While not truly real-time, these gauges allow residents and officials to check stream levels within the current hour. In addition, by clicking on a desired location, it is easy to see how quickly the streams are rising or falling. On-going efforts from the NWS and USGS are determining the critical levels at which flooding of structures and roads begin. Below are the NWS' Advanced Hydrologic Prediction Service links to McAlpine Dam.

Upper gauge: http://www.crh.noaa.gov/ahps2/hydrograph.php?wfo=lmk&gage=mluk2
Lower gauge: http://www.crh.noaa.gov/ahps2/hydrograph.php?wfo=lmk&gage=mlpk2
Click on the "River at a Glance" link.

CoCoRaHS

NWS assisted in the initiation of "Community Collaborative Rain, Hail & Snow" (CoCoRaHS) in Kentucky where volunteers work together to measure precipitation across the nation.

Promote "Turn Around and Don't Drown"

(NWS Video) – NWS promotes this initiative, and will make the video/CD available to MetroTV, as well as other media outlets.

Tornado Weather Spotter Program

The National Weather Service sponsors The Weather Spotter program. The Emergency Management staff coordinates with the NWS to train various groups around the community to become Weather Spotters. These trained people are the local eyes and help the NWS warn the public of possible severe weather.

Emergency Management

The following various EMA programs are detailed on their website at:
http://www.louisvilleky.gov/ema

Warning Systems

Louisville Metro EMA manages and coordinates the Outdoor Warning System, which consists of over 120 Sirens in various locations around the Metro area. These devices are activated from the 24-hour 911 (MetroSafe) communication center with back-up activation capability at two communication centers. The system is tested monthly with weekly diagnostic tests performed silently and SOPs for the siren operation are developed and reviewed annually. Other warning systems located at the 24-hour warning point include Emergency Alert System (EAS), MetroCall, 1610 AM radio, TRIMARC Transportation System and the Cable Interrupt system. Warning systems that are monitored include the NOAA weather radio and several computer generated weather programs to keep a watchful eye on possible weather conditions that would affect Louisville Metro.

Facility Shelter Surveys/Disaster In-services-training
This program coordinates several activities that assist various private/public schools, colleges/universities, businesses, churches, and community groups in planning for disasters. This process usually starts with a facility visit to conduct a survey, which will identify and designate potential shelter safe areas. After the initial survey, several documents that will assist the facility in building their own emergency plan are presented. Annual in-service training for all potential hazard events is practiced. Tornado and Shelter-in-Place training are the most widely requested topics for in-services.

The Louisville/Jefferson County Local Emergency Planning Committee (LEPC)
The LEPC is responsible for developing the Community Response Plan, but implementation of the plan is the responsibility of local government as a means of protecting life and property. The LEPC has coordinated development of the plan with local officials and agency personnel who implement it for a hazardous material incident. This plan provides guidance for response to a hazardous materials release from a facility which manufactures, uses or stores such substances. Agency personnel who are likely to provide on-site support should develop detailed Standard Operations Procedures which reveal names and quantities of hazardous materials, include storage areas and manner of storage, identify adverse health and environmental effects of exposure to the chemicals, and provide specific operations procedures relating to the agency.

Hazardous Material Emergency Response
The Emergency Management program supports the Hazardous Materials Program by participating in the on-call rotation, attending training, and responding, to chemical emergencies or other related events. The HazMat Training Program sponsors training for both the hazmat response community and LEPC personnel. Working in partnership with the Kentucky Emergency Response Commission, KyEM annually sponsors courses to support the OSHA training levels, such as Emergency Response Guidebook, Hazardous Materials Awareness, Hazardous Materials Operations, and NIMS 300/400 Compliance. KyEM works with a volunteer cadre of local HazMat instructors along with paid instructors from the State's Fire/Rescue Training Program to deliver HazMat Awareness and Operations training.

Chemical Stockpile Emergency Preparedness Program (CSEPP)
In the unlikely event of a chemical agent, the planning process between the U.S. Army and FEMA assists state and local governments in improving emergency planning and preparedness in communities near chemical weapons storage sites in their community. This CSEPP process requires coordination of local military and civilian efforts and ensures that decisions will be made and carried out effectively in a crisis.

Healthcare Emergency Response Association (HERA)
The mission of HERA Region 6 preparedness committee is to support the development of cooperative partnerships in order to promote and enhance the disaster preparedness of the community's healthcare and emergency response system(s) through coordinated disaster preparedness, education, public outreach, and response and recovery activities. HERA has created an All Hazards Plan, which helps hospitals during disasters; additionally all HERA hospitals have signed the Kentucky Hospital Association Mutual Aid Compact, which is a mutual aid agreement for all hospitals throughout the Commonwealth.

Metropolitan Medical Response System (MMRS)
The MMRS is an ongoing effort by the public health and safety community in Louisville Metro to plan for serious health and medical catastrophes that threaten public health (terrorism,

epidemics, etc.), to develop systems for coordinating and providing critical care where it is needed and to purchase medicine and equipment. Louisville Metro EMA has joined with agencies throughout Bullitt, Henry, Jefferson, Oldham, Shelby, Spencer and Trimble counties in Kentucky and Clark and Floyd counties in southern Indiana to effectively respond to disasters.

Terrorism & Weapons of Mass Destruction
Louisville Metro EMA staff has received training for any event that might disrupt normal daily activities, such as terrorism or the use of a weapon of mass destruction. Louisville Metro EMA attends regularly scheduled training sessions and response is incorporated into the EOP.

National Defense Medical System (NDMS)
The NDMS is designed to care for the victims of an incident, like 9-11, that exceeds the medical care capability of an affected state, region, or federal medical care system. NDMS plans for treating large numbers of casualties in a major peacetime disaster or national security emergency involving a conventional military conflict. The Emergency Management program is responsible for coordinating efforts with local hospitals, the Department of Defense, FEMA, the Veterans Administration, and Health and Human Services in the event of the activation of this system.
NDMS is capable of treating large numbers of casualties injured in a major peacetime disaster or a national security emergency involving a conventional military conflict. The NDMS fulfills three main objectives:

1. Provide supplemental health and medical assistance in domestic disasters at the request of state and local authorities.
2. Evacuate patients who cannot be cared for in the disaster area to designated locations elsewhere in the nation.
3. Provide hospitalization in a national network of hospitals to care for the victims of a domestic disaster or military contingency that exceeds the medical care capability of the affected local, state, or federal medical system.

Louisville Medical Reserve Corps (MRC)
MRC has trained over 1,200 volunteers. The MRC is comprised of medical and non-medical people who are willing to volunteer their time and expertise to supplement existing public health and local resources during times of emergencies and community need. The Louisville MRC has once again been selected to receive a capacity building grant from the National Association of County and City Health Officials (NACCHO). The grant will be utilized to recruit and train new MRC volunteers.

Since 2008, MRC volunteers have assisted the Louisville Metro Department of Public Health & Wellness in staffing special needs shelters when Louisville Metro hosted the Hurricane Gustav evacuees, during the 2008 windstorm and during the 2009 ice storm. They also assisted during the H1N1 vaccination campaign in 2009 and assisted with the vaccination of Jefferson County Public School (JCPS) students at sites where 80% of the students qualify for free or reduced lunches in 2010.

In March 2011, the Kentucky Department for Public Health offered a free workshop to provide training for volunteers interested in offering assistance during public health emergencies. This exciting event will provide new MRC volunteers an opportunity to complete all of the training required to join the MRC in one day. Over three hundred people registered for the event.

Grant Applications

Louisville Metro has taken advantage of several opportunities to garner federal money in a post-disaster setting. As a result, acquisitions have taken place all over the county. FEMA Grant application projects types vary by 3 categories, e.g., Planning, Initiative, and Projects (i.e., Construction, Drainage, and Acquisition/Demolition). Submitted Letter of Intents (LOI) are prioritized by KyEM as to whether or not the project is located in an affected disaster area. If so, the project does take precedence over counties that were not in the designated disaster area. Louisville Metro has been in the declared area for the last 3 Kentucky disasters. Following is a profile of existing grant applications.

Mitigation Grant Profiles

Underway

HMPG Awarded

Awaiting Review and Approval

5.2.4. Mitigation Success Stories

Louisville Metro has been very successful to-date with mitigation activities, including regulatory and legislation actions. The annual progress report details any project revisions, updates and successes and revises the five-year Plan accordingly. A sampling of successful mitigation actions is included here. A status report for all of the mitigation actions and strategies from the 2011 Plan can be found in Appendix F.

5.3. Mitigation Goals

During the February 7 Project Team meeting the Team decided to keep the Mitigation Goals from the 2011 Plan. The Team also decided to remove the Objectives because they were duplicative of the actual mitigation strategies.

Goal 1
Minimize the loss of life and injuries that could be caused by multi-hazards.

Goal 2
Facilitate a sustainable economy by protecting agriculture, business, and other economic activities from multi-hazards.

Goal 3
Facilitate the strengthening of public emergency services, its infrastructure, facilities, equipment, and personnel to multi-hazards.

Goal 4
Develop a community-wide mitigation effort by building stronger partnerships between government, businesses, and the general public.

Goal 5
Increase public and private understanding of multi-hazard mitigation through the promotion of mitigation education and awareness of multi-hazards.

Goal 6
Enhance existing or design new policies and technical capabilities that will reduce the effects of multi-hazards.

Goal 7
Enhance existing technical and GIS data and capabilities that will reduce the effects of multi-hazards.

5.4. Mitigation Strategies

All mitigation strategies from the 2011 Plan were reviewed by the project team and stakeholders. Completed or outdated strategies were removed and incomplete or ongoing strategies were renewed. Several new strategies were added as well.

All strategies were scored on a prioritization matrix considering relative cost and community benefit.

Identification and Analysis of Mitigation Measures

Requirement §201.6(c)(3)(ii): The mitigation strategy shall include a section that identifies and analyzes a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure.

5.4.1. Prioritization and Benefit-Cost of Mitigation Actions

Mitigation action prioritization emphasizes the extent to which benefits are maximized, according to a review of the proposed projects and their associated costs. Through the Benefit-Cost Prioritization Matrix, the higher the action's benefit, and the lower the cost, the more cost beneficial and higher priority the action was determined to be for the community.

The benefit scale is based on FEMA's Mitigation Action Evaluation Worksheet see Appendix X. For each Action, the potential benefits were evaluated and/or the likelihood of successful implementation for the following criteria:

Mitigation Benefit Scale	
Ranking	**Description**
A Very High	Projects or activities which score 8 or higher on the Evaluation Worksheet
B High	Projects or activities which score 6 or 7 on the Evaluation Worksheet
C Medium	Projects or activities which score 4 or 5 on the Evaluation Worksheet
D Low	Projects or activities which score 3 or lower on the Evaluation Worksheet.

Life Safety
Property Protection
Technical Feasibility
Political Feasibility
Legal Status
Environmental Impacts
Social Impacts
Administrative Capability
Local Champion
Advance other Community Objectives

Once the benefit of the project was determined, the project team convened to determine the priority of each action item based on the following Prioritization Matrix. This simplified decision-making chart, uses rough cost estimations and the mitigation benefit scale to assign a prioritization ranking for each action item. Those action items that receive a higher ranking signal projects that should receive special attention. Inversely, projects that are estimated to be higher in cost with a lower benefit receive a lower ranking.

Benefit-Cost (B-C) Prioritization Matrix					
		Benefit			
		D (Low)	C (Medium)	B (High)	A (Very High)
Cost	Very High	Low	Low	Medium	Medium
	High	Low	Medium	High	High
	Medium	Medium	High	High	Very High
	Low	Medium	High	Very High	Very High

Mitigation Strategies were divided into six sections.

1. All Hazards
2. Flood Hazards
3. Dam/Levee Hazards
4. Meterorologic Hazards (Tornado, Severe Winter Storm, Severe Storm, & Hail
5. Geologic Hazards (Earthquake, Landslide, & Karst/Sinkhole)
6. Other Hazards (Drought, Extreme Heat, Wildfire, HazMat)

Strategy Number	Hazard Type	Type of Activity or Project	Proposed Schedule	Lead Implementer & Contact Person	Other Proposed Partners	Benefit-Cost Prioritization	Funding/ Budget Considerations
1.1	**All Hazards**	**For Publicly Owned Buildings and Essential Facilities** 1. Develop Risk Assessment of Publicly owned buildings, essential facilities, and transportation. (See Flood # 4). 2. Review Evacuation Plans for Central downtown government Public Buildings. 4 Disseminate Safe Room locations. 3. Develop/Revise Emergency Action Plans (EAP), as needed 4 Disseminate Safe Room locations.	Grant dependent	EMA – Jim McKinney	PVA, JCPS, KYTC, KIPDA, TARC, LOJIC, Metro Facilities Manangement, Metro Public Works, Develop Louisville		Normal Operating Budget, Grant Request from general funding
1.2	**All Hazards**	**Develop risk assessment with best available building data** **Collect Additional Enhanced Building Data.** A major research project: 4 Year built, especially structures older than 1980 4 Type of foundation, building construction type, number of stories	Grant dependent	TBD special project required	LOJIC, Fire Inspections, Metro Police, Metro Facilities, Public Health, Local Hospitals, PVA, JCPS, IPL		Resources needed, Request from state or federal funding or grant
1.3	**All Hazards**	**Develop Risk Assessment: Research the Existing Collected Data and Incorporate Inventory into LOJIC** PDS to collect standardized historical data. Next steps: 1. Historical Structures Survey. 2. Inventory of public buildings: review data for accuracy and completeness. 3. Incorporate data into LOJIC Metro PDS and PVA will work with LOJIC to coordinate the inventory. *See Flood #4.*		LOJIC - Curt Bynum	PVA, Develop Louisville, Metro Public Works, Metro Facilities		Normal Operating Budget, Resources needed
1.4	**All Hazards**	**Mitigate Public Transportation, Public Buildings and Utility Infrastructure** 1. To retrofit for hazard events (wind loads, seismic shock and floodproofing) use Risk Assessment from Phase 2 and research existing: 4 Transportation 4 Public Buildings and 4 Utility Infrastructure 2. Develop a strategy and program to retrofit structures at-risk. 4 Target structures that may need protection for each hazard. 3. Collect information and develop appropriate mitigation strategy to retrofit *See Flood #4.*	Grant dependent	MSD -David Johnson, LG&E – Keith Alexander, LWC – Glen Mudd, Jeffersontown - Matt Muneier	Metro EMA, Metro Public Works, KYTC, KIPDA, TARC, TRIMARC, LRAA		Normal Operating Budget, Grants, Possibility of grant funding through Silver Jackets

Strategy Number	Hazard Type	Type of Activity or Project	Proposed Schedule	Lead Implementer & Contact Person	Other Proposed Partners	Benefit-Cost Prioritization	Funding/ Budget Considerations
1.5	All Hazards	**Prepare for Special Needs At-Risk Groups During Disaster**1. Develop Special needs preparedness program2. Develop "Special needs registry"3. Promote campaign to self-identify if special needs in household4. Build a Special needs database to help plan for response activities and shelters and evacuationUse www.disability.gov as resource	Grant dependent	EMA-Jim McKinney	Public Health, ARC, KIPDA, Office of Community Services & Revitalization, Office of Housing and Community Development		Normal Operating Budget, Grants
1.6	All Hazards	**Data Collection for Hospital Patient Discharge Data** 4 Emergency Department patient discharge data for preparedness epidemiologist for six syndromes 1. Cardiac (chest pain), 2. G.I. (vomiting, diarrhea), 3. Neurological (seizures, paralysis), 4. Respiratory (difficulty breathing, symptoms of asthma), 5. Psych (mental status change, emotional instability) and 6. Other: Infectious Disease 4 will require purchase of telecomm/software to facilitate sharing of hospital data to MPH	Grant dependent	Public Health – Steve Hosch, Matt Rhodes, Dr. Faye Saad	Hospitals		Normal Operating Budget
1.7	All Hazards	**Health Impact Assessment "Tool" to Develop Projects** 4 For evaluation of proposed development projects in connection with the potential ramifications to the health and wellness of stakeholders. 4 The Health Impact Assessment is in early stages. A committee will be formed in early 2011 and will develop and pilot an assessment tool.	Grant dependent	Public Health - Steve Hosch and Matt Rhodes	Develop Louisville, Metro Parks, Metro Public Works, LMPD		Normal Operating Budget, Grants
1.8	All Hazards	**Community Health Education "clearinghouse"** 4 Promotion potentially partnering with others to serve as a "clearinghouse" 4 Will help people find proper resources for such things as health screenings, existing education or outreach programs, etc. 4 Public Health currently working to develop a list of resources. Developing strategy to better promote a coordinated service.	Ongoing	Public Health - Steve Hosch and Matt Rhodes	ARC, KY VOAD, KY DPH		Normal Operating Budget
1.9	All Hazards	**Increase Training for WebEOC**4 Increase training for more people to use Web EOC.4 Set a schedule4 Develop list of potential candidates.	Ongoing	EMA – Jim McKinney & Tonja Medic	Mayor's office, MetroSafe/911		Normal Operating Budget

Strategy Number	Hazard Type	Type of Activity or Project	Proposed Schedule	Lead Implementer & Contact Person	Other Proposed Partners	Benefit-Cost Prioritization	Funding/ Budget Considerations
1.10	All Hazards	**Develop inventory of barricades and signage that can be used during hazard events and develop system for deployment**	2017	PW- Jeff Brown	Metro EMA, MetroSafe/911, LOJIC, TARC, LWC, LG&E, LMPD, MSD, Metro/Suburban Fire, TRIMARC, KYTC		Normal Operating Budget
1.11	All Hazards	**Emergency Generators in Public Schools** 4 Eighteen emergency generators to completely supply electrical power for all shelters both for the school system and the community. 4 Begin project by prioritizing facilities to receive generators.	Grant dependent	JCPS - Dave Self	Metro EMA, ARC		Normal Operating Budget, Grants
1.12	All Hazards	**Oxygen Generators in Ambulances for EMS** 4 Generators for EMS to charge life-saving equipment, e.g., oxygen	Grant dependent	Metro EMS –	Metro EMA		Normal Operating Budget, Grants
1.13	All Hazards	**Emergency Preparedness Training for Public Schools** 4 Provide funding for professional development for administrators for Mitigation, Preparedness, Response and Recovery through JCPS' Safety Procedures Manual training. 4 Additional FEMA Introduction to Incident Command for Schools course would also be administered. 4 Promote self preparedness. 4 Partner w/ KyEM for instructors and materials	Grant dependent	JCPS - Dave Self	Metro EMA, KyEM, Homeland Security, KCTCS, KY Education Cabinet		Normal Operating Budget, Grants
1.14	All Hazards	**Emergency Communication for Public School Buses during Disaster** 4 To enhance communication systems through 2-way radio system compatible with MetroSafe including radios for buses.	Grant dependent	JCPS - Dave Self	Metro EMA		Normal Operating Budget, Grants
1.15	All Hazards	**Emergency Supply Kits for Public Schools** 4 Basic emergency supply kit for schools and medical/medicine storage – to have minimal storage for medicines and records for school.	Grant dependent	JCPS - Dave Self	Metro EMA		Normal Operating Budget, Grants
1.16	All Hazards	**During Emergency Hazard Event Response** 4 Portable water purification systems	Grant dependent	Metro Public Health - Linda Hawkins	Metro EMA, Metro Public Health, LWC, National Guard		Normal Operating Budget, Grants
1.17	All Hazards	**CHAMPS implementation and training for Lousville Metro**	Grant dependent	KYEM - Doug Eades	Metro EMA, Metro Public Health, ARC, LG&E, JCPS, MetroCall, LOJIC, NWS, KyEM, KDOW		Normal Operating Budget, Grants, State Planning

Strategy Number	Hazard Type	Type of Activity or Project	Proposed Schedule	Lead Implementer & Contact Person	Other Proposed Partners	Benefit-Cost Prioritization	Funding/ Budget Considerations
1.18	**All Hazards**	**Increase Business Partnerships and the Creation of COOP planning**	Grant dependent	Metro EMA - Jody Meimam	Metro Public Health, GLI, Louisville Forward, KIPDA, UofL Department of Urban & Public Affairs		Normal Operating Budget, Grants
1.19	**All Hazards**	**Public Education & Standard Public Statements for All Hazards** 1. Promote use of early warning systems in multiple languages for standard outreach materials 2. Utilize recording by MetroCall 311 to disseminate brief information on hazards. 3. Use Greater Louisville TV (GLTV) for awareness messages. 4. Utilize News media for public education and event notification 5. Promote better personal planning/public education for disaster preparedness 6. Utilize LEPC "Fact Sheets" for educational and public outreach to ensure consistent message for ARC, Health Dept., EMA, LG&E, Dept. of Education, 7. Partner with known disability advocacy organizations to target preparedness messages and threat alerts to vulnerable populations (hearing impaired, visually imparied, homeless, linguistically isolated, etc..)	TBD for each project	EMA -Jim McKinney NWS - John Gordon & Joe Sullivan	ARC, JCPS, NWS, Metro/Suburban Fire, KYEM, Metro Public Health, MSD, USGS, LMPD, LG&E, USACE, LWC, Local media outlets, Metro TV, MetroCall - 311, Metro United Way - 211		Normal Operating Budget, Grants
1.20	**All Hazards**	Increase registration for LENS/CodeRed to XX%	2017	EMA Jim Bottom	Faith Organizations, VOAD, TV & Radio Stations		
1.21	**All Hazards**	Utilize JCPS weather stations being installed on 15-20 schools as part of UofL study on urban heat island to get real-time data, including temp, dew point, precipitation, winds, and barometric pressure		NWS - Joe Sullivan, JCPS - Dave Self	Metro Sustainability, MSD		
1.22	**All Hazards**	Re-establish bi-annual hazard mitigation stakeholders and implementers, update funding and progress, coordinate with Silver Jackets	Ongoing	EMA - Jim McKinney, MSD - Lori Rafferty & JP Carsone			
1.23	**All Hazards**	**Botanica, Waterfront Botanical Garden** - 23 acre water retention project including utilizing runoff for irrigation. Educational compenent includes air, water, and waste sustainability projects. Projects sits on river, Beargrass Creek, and is an old city landfill. Site will be planted with trees - lots of trees.	2017	GLI - Tim Corrigan	MSD, Metro Sustainability, Metro Parks		Grants, $7million in private funds already raised

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2.1	**Flood**	**Update Floodplain Ordinance** 4 Particularly the enforcement section 4 Review criteria for enclosure limits	In process, 2016 adoption	MSD – David Johnson	KDOW – NFIP	High	Normal Operating Budget
2.2	**Flood**	**Flood Studies for Mitigation** Update flood models in areas with known flooding issues and problematic modeling, including the 10-year flood interval, specifikcally including: - Greasy Ditch - Buechel Branch - Brooklawn Tributary	As budget is available	MSD – Lori Rafferty	Private Development Community, USACE	High	Normal Operating Budget, Grants
2.3	**Flood**	**Mitigation: Project to Protect Existing Buildings And Infrastructure** Target at-risk public and private buildings from flood for mitigation/retrofit 1. Inventory public buildings at-risk (also, see All Hazards # 4 & 5) 2. Develop a plan for mitigation for public property. 3. Develop a plan for mitigation for private property.	in process, complete 2016	MSD – Lori Rafferty, LOJIC – Curt Bynum, Jeffersontown - Matt Meunier	Metro Public Works, Metro Facilities, JCPS, Louisville Free Public Library	Medium	Normal Operating Budget for inventory and strategy, Grants for retrofit
2.4	**Flood**	**Future Floodplain Buyouts Throughout The County** 4 Identify repetitive loss, severe repetitive loss candidates, and other floodprone properties 4 Prepare grant applications as funds become available	Grant dependent	MSD – David Johnson, Lori Rafferty	Metro EMA, KyEM	High	Grants
2.5	**Flood**	**Acquisitions in Western Louisville CSSA Area** See list of potential areas at the end of the Flood section	Grant dependent	MSD – Lori Rafferty	Metro EMA, KyEM	High	Grants
2.6	**Flood**	**Place Flood Elevation Markers or Other Signage Along Floodprone Roads and Parking Areas** Especially roads that are frequently overtopped to demonstrate to drivers/pedestrians how deep the water is 4 Complete an inventory of current sign locations 4 Develop strategy for other at-risk areas 4 Post signs		MSD - Jill Allen, Metro Public Works - Jeff Brown	NWS, Metro Parks, KYTC, Suburban Cities	Medium	Normal Operating Budget

Strategy Number	Hazard Type	Type of Activity or Project	Proposed Schedule	Lead Implementer & Contact Person	Other Proposed Partners	Benefit-Cost Prioritization	Funding/ Budget Considerations
2.7	**Flood**	**Review and Update Flood Related Emergency Preparedness and Response Plans including evacuation of at-risk populations including seniors and disabled.** 4 Complete an inventory 4 Review Plans 4 Update Plans	Ongoing	Metro EMA - Jim McKinney, MSD - JP Carsone	USACE, LMPD, All Fire Districts, NWS, Mayor's Office, Metro Public Works, Metro Office of Community Services and Revitalization, Metro Office of Housing and Community Development	Very High	Normal Operating Budget
2.8	**Flood**	**LaClede Basin** – Proposed flood control basin located near end of W. Indian Trail and Greasy Ditch	Grant dependent	MSD – John Loechle, Lori Rafferty		High	Grant
2.9	**Flood**	**Tin Dor Way Basin** - proposed flood control basin in Fairdale near Tin Dor Way If flood control basin is not feasible, then develop strategy for possible buyouts	Grant dependent	MSD – John Loechle, Lori Rafferty		High	Grant
2.10	**Flood**	**Bluegrass Avenue Box Culvert** – remove the 'reverse' invert (remove siltation) and possibly add a second barrel at this intersection. 4 Part 1 – Maintenance of existing 4 Part 2 – Identify and implement other improvements	In process, 2016 completion	MSD - Tony Marconi	Metro Public Works, USACE, JHSMH		Normal Operating Budget, Grant, $300,000
2.11	**Flood**	**Flood Pump Stations** 1. Rehab, replace and update flood pump stations 2. Inventory and verify emergency generators and backup. Apply for grants where needed.	Ongoing	MSD – Darren Thompson	USACE	Medium	Normal Operating Budget, Grants, WRDA
2.12	**Flood**	**Metro Parks Reviewing Its Buildings For Flood Damage Mitigation** 4 Reviewing backflow prevention devices, floor drains, sump pumps, gutters and downspouts, and sheet runoff diversion. Develop inventory. 4 Mitigation projects identified in this review will be placed on repair schedule 4 Accomplished as funds permit over the next five years.	Ongoing	Metro Parks – Jason Canuel	MSD – Backwater Valve program		Normal Operating Budget

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2.13	**Flood**	**Establish and Coordinate Tree Programs And Partnerships To Increase Tree Canopy, Parkway Areas** Metro Parks and MSD are expanding the tree canopy in the metropolitan area. Part of the plant 10,000 trees campaign. Partner with PDS to increase canopy on parkway areas 4 Metro Parks will continue over the next five years to replace trees along parkways and in landscaped park areas as needed to retain tree canopy cover in the metropolitan area.	Ongoing	Metro Parks – Jason Canuel and Mesud Duyar, MSD - Jordan Basham	Metro Sustainability	Medium	Normal Operating Budget
2.14	**Flood**	**Public Outreach about Basement Flooding** 4 Education of the public from keeping critical items out of basements – computers, books, important files etc..... 4 Target the audience on regulatory floodplain or MSD customer service requests rather than just the FEMA floodplains	Ongoing, annual letter to everyone in floodplain and repetitive loss properties, Louisville Magazine and Business First advertisements	MSD – Lori Rafferty-and Sheryl Lauder	Media, LFPL	High	Normal Operating Budget
2.15	**Flood**	**Public Outreach: Evaluate Ways to Get Message to a Targeted Audience** Message is to better educate the public regarding floodprone areas including flood insurance and plumbing modification programs	Ongoing, annual letter to everyone in floodplain and repetitive loss properties.	MSD – Lori Rafferty-and Sheryl Lauder	Media, LFPL	High	Normal Operating Budget
2.16	**Flood**	**Mitigation: Develop program for Non-profit retrofitting** Investigate non-profit/humanitarian home building entities for low-income floodproofing/retrofitting projects in a floodprone area.	Grant dependent	MSD - Pat Barry	Corporate sponsors, JCPS, Habitat for Humanity, BIA, Metro Office of Housing and Community Development		Grants
2.17	**Flood**	**Increase Coordination of Flood Warning using NWS Chat Rooms** NWS Chat Rooms are set up to coordinate with staff in an official capacity. Several chat rooms exist, and NWS can set up additional ones if needed. Chat Rooms already include USGS, Corp, media, & EMS and can be made available to other agencies.	Ongoing	NWS – Joe Sullivan	USGS, USACE, MSD, Media, Metro EMS, Metro EMA	Very High	Normal Operating Budget
2.18	**Flood**	**Construct additional rain gages and stream gages on un-gaged streams to be used for warning, forecast flooding**	Grant dependent	MSD- JP Carsone, Lori Rafferty	USGS, EMA, USACE, NWS	Medium	Grant dependent

Strategy Number	Hazard Type	Type of Activity or Project	Proposed Schedule	Lead Implementer & Contact Person	Other Proposed Partners	Benefit-Cost Prioritization	Funding/ Budget Considerations
2.19	**Flood**	**Elevation of floodprone properties along the Ohio River** - Phase 1 - Determine if elevation is feasible and cost effective for existing floodprone homes. - Phase 2 - If feasible, elevate homes to at least one foot above the local regulatory floodplain elevation	Phase 1 - 2018, Phase 2 - Grant dependent	MSD - Lori Rafferty	FEMA, KyEM	Medium	Phase 1 - Normal Operating Budget, Phase 2 - Grant dependent
2.20	**Flood**	**Drainage improvement projects to reduce structural flooding**, such as upsizing culverts, constructing detention basins, and widening channels - Phase 1 - Complete studies for areas with structural flooding concerns - Phase 2 - Construct cost effective projects determined to be feasible in studies	Phase 1 - 2017, Phase 2 - Grant dependent	MSD - Stephanie Laughlin	Small cities (Jeffersontown, Hurstbourne, Prospect, etc), FEMA, KyEM	HIgh	Phase 1 - Normal Operating Budget, Phase 2 - Grant dependent

Strategy Number	Hazard Type	Type of Activity or Project	Proposed Schedule	Lead Implementer & Contact Person	Other Proposed Partners	Benefit-Cost Prioritization	Funding/ Budget Considerations
3.1	**Dam & Levee Failure**	**Risk Assessment: Develop A Dam & Levee Risk Assessment With Best Available Data** **PHASE 1: Verify GIS locations for existing dams**. Develop data inventory of all dams within Louisville Metro area. Steps: 4 Collect data from KDOW for locations and assessment of the State-Owned dams. 4 Perform research in the State Dam Safety Program records, which requires an "Open Records" request to the KDOW. 4 Research records and locations of dams within metro boundaries. 4 From research, collect other important data, e.g. current EOPs, dam materials, past inspections, violations, etc… 4 Collect inventory of dam locations and geo-code. 4 Verify which Class C dams have an EOP. * FEMA grant submitted in December 2010 by Metro	2017 for research, Mapping complete, EOPs in process, inspections complete for Class C, inundation maps completed in 2014, all Class C have EOP	MSD - Tony Marconi, LOJIC - Curt Bynum, KDOW Dam Safety Program - Marilyn Thomas	NRCS, Metro/Suburban Fire Districts, Metro Parks, USACE - Brandon Brummett	High	Grants, Normal operating Budget for maps
3.2	**Dam & Levee Failure**	**PHASE 2: Perform Risk Assessments on Class B and C Dams** **Class C, High-Hazard Dams** 4 Verify all Class C dams have and maintain an EOP (tied to above action item results). 4 Verify downstream warning system, public notice, etc. are included in EOP. **Class B, Moderate/Significant Risk Dams** 4 Assess Class B dams for any downstream construction that might raise dam classification	In process, risk assessments complete for Class C	MSD - JP Carsone, Metro Parks - Jason Canuel	KDOW, Private Dam Owners, LOJIC, USACE - Brandon Brummett	High	Grant dependent
3.3	**Dam & Levee Failure**	**Mitigation: Develop EOPs for Class C Dams** 4 Develop EOPs for dams without plans 4 Update existing EOPs. 4 Add NWS notification for alerts via weather radios	In process	MSD - Lori Rafferty, Metro Parks - Jason Canuel, KDOW - Carey Johnson	Private Dam Owners, Metro EMA, NWS, LOJIC, USACE - Brandon Brummett	High	Normal Operating Budget, Potential new budget item or grant funding
3.4	**Dam & Levee Failure**	**Mitigation: Post a Sign/Landmark On Dams With Classification Type (A, B, or C).** * Signs to include: 4 Contact numbers 4 Name of dam 4 Maximum water impoundment * *Project dependent upon dam inventory (Phase 1)*	Dependent upon dam inventory (Phase 1)	MSD - Tony Marconi	KDOW, Private Dam Owners, Metro EMA, LOJIC, Metro Parks, USACE - Brandon Brummett	Medium	Potential new budget item or grant funding

Strategy Number	Hazard Type	Type of Activity or Project	Proposed Schedule	Lead Implementer & Contact Person	Other Proposed Partners	Benefit-Cost Prioritization	Funding/ Budget Considerations
3.5	**Dam & Levee Failure**	**Mitigation: Removal or Replace Unsafe Dams** Once inspections are complete, the list of unsafe dams will determine next steps for repair and/or removal of dams. An unsafe dam would move to a Priority A project for immediate action. * *Project dependent upon dam inventory and assessment (Phases 1 & 2)*	Ongoing	KDOW Dam Safety Program - Marilyn Thomas	NRCS, Private Dam Owners, LOJIC, MSD, Metro Parks, USACE - Brandon Brummett for Low Head Dam removal	High	Metro Parks MSD Capital Projects NRCS
3.6	**Dam & Levee Failure**	**Risk Assessment and Mitigation** 4 Place a benchmark or similar point on dams to determine if movement is occurring. 4 Benchmark placement should coincide with inspection and data development.	Phase 1 & 2 dependent	Metro Parks - Jason Canuel, MSD - Tony Marconi, KDOW Dam Safety Program - Marilyn Thomas	Private Dam Owners, Metro EMA, Develop Louisville, LOJIC, USACE - Brandon Brummett	High	Potential new budget item or grant funding
3.7	**Dam & Levee Failure**	**Consider Requiring EOP for Class B Dams** 4 Class B dams have at-risk structures below the levee, therefore should require an emergency plan. 4 Partner with KY DOW Dam Safety Program for requirements and regulations	Phase 1 & 2 dependent 2015	KDOW Dam Safety Program – Marilyn Thomas	MSD, Metro Parks, Private Dam Owners, LOJIC, USAC - Brandon Brummett	Very High	Normal Operating Budget
3.8	**Dam & Levee Failure**	**Mitigation: Evaluate Damage To Levee And Flood Protection System** Primarily Ohio River Flood Protection System and large pump stations (i.e. Beargrass Creek). Corps annual inspection is ongoing. Five-year inspection is more detailed	Ongoing maintenance, bi-annual inspections by MSD, annual inspections by USACE	MSD-Daren Thompson, USACE - Brandon Brummett	LG&E	HIgh	MSD funded; estimated at $2.2 million/yr. ($38 million Total Est. Cost)
3.9	**Dam & Levee Failure**	**Mitigation: Develop Better Local Dam Construction And Inspections Criteria** In order of the following: 1. Develop inspection and construction criteria to review existing dams 2. Begin periodic dam Inspection to develop reports. Metro Parks has a plan in place and performs regular inspections.		Metro Parks - Jason Canuel, MSD - Lori Rafferty	KDOW, Private Dam Owners, Metro EMA, Develop Louisville, USACE - Brandon Brummett	High	Normal Operating Budget, Grants
3.10	**Dam & Levee Failure**	**Metro Parks Remedial Work on their Dams** Remedial work needs to be competed on some dams 4 Maintenance and inspection needed 4 Coordinate with MSD	-	Metro Parks - Jason Canuel	MSD, USACE - Brandon Brummett		Normal Operating Budget, Grants
3.11	**Dam & Levee Failure**	**Public Awareness** 4 Signage of the flood protection system history and assets, indicate allowed/prohibited activities		MSD - JP Carsone	Corp of Engineers- Brandon Brummett KDOW	Medium	Normal Operating Budget

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Strategy Number	Hazard Type	Type of Activity or Project	Proposed Schedule	Lead Implementer & Contact Person	Other Proposed Partners	Benefit-Cost Prioritization	Funding/ Budget Considerations
3.12	**Dam & Levee Failure**	**Ash Ponds** – HazMat Ensure they are safe	Ongoing	LG&E - Keith Alexander, KDOW - Marilyn Thomas	EPA, Metro EMA, USACE - Brandon Brummett		Normal Operating Budget
3.13	**Dam & Levee Failure**	**24-hour high hazard dam monitoring and warning system for those in inundation area**	2017	MSD - Jill Allen & Marc Thomas, USGS - TomRuby	LG&E, Metro Parks, USACE - Brandon Brummett, KDOW Dam Safety, USGS, Property Owners	High	Silver Jackets
3.14	**Dam & Levee Failure**	**Catastrophic Flood/Levee Failure Planning Study**	2018	MSD - JP Carsone	Metro EMA, KyEM, APCD, USACE, KDOW, Business Owners, Louisville Forward, Develop Louisville, SilverJackets, LMPD, LMFD, Suburban fire districts, Metro EMS, KOSHA,	High	SilverJackets, Grants

Strategy Number	Hazard Type	Type of Activity or Project	Proposed Schedule	Lead Implementer & Contact Person	Other Proposed Partners	Benefit-Cost Prioritization	Funding/ Budget Considerations
4.1	**Meteorologic**	**Find Location And Build Tornado Shelters/Safe Rooms For Minors Lane Neighborhood** 4 Tornado shelter/safe room for Minors Lane Neighborhood property. Minors Lane school is being opened for the community during severe storm warnings for 2 manufactured home parks. o A separate 24-hour available independent shelter is desperately needed. This would give immediate access to the community. 4 Research location at manufactured home parks, JCPS, and/or UPS property	Grant dependent	Metro EMA - Jim McKinney, JCPS - Dave Self	UPS, Manufactured home park		Normal Operating Budget, Grants, Estimated cost = $200,000
4.2	**Meteorologic**	**Promote Safe Rooms/Tornado Shelter for New Construction** 1. Encourage new construction to include a safe room. Tax incentive for property tax for constructing tornado safety room in house 2. Require all new manufactured home parks to build a safe room. Tornado Shelters for manufactured homes. 3. ARC work with the BIA to build safe rooms.	2017	NWS - John Gordon & Joe Sullivan, Jeffersontown - Matt Meunier	Develop Louisville, Metro Council, Insurance Coompanies, Codes and Regulations, Manufactured home parks, ARC, BIA, GLAR		Normal Operating Budget
4.3	**Meteorologic**	**Increase Awareness of Outages During an Event** 4 Outbound calls from LG&E re: outages 4 Mapping on websites	Ongoing	LG&E - Keith Alexander	Media Mayor's office EMA MSD EMS		Normal Operating Budget
4.4	**Meteorologic**	**Promote & Distribute Weather Radios**	Ongoing	NWS -John Gordon, Mike Callahan & Joe Sullivan	Metro EMA, Corporate sponsors, BIA, ARC		Grants
4.5	**Meteorologic**	**Public Outreach on Retrofitting, Mitigation, Education and Wind-Driven Building Techniques** 1. Develop standardized message and program for how to make a home wind resistant 2. Partner with KY Weather Preparedness Committee (KWPC) that applied for a grant to buy FLASH (Federal Alliance for Safe Homes) cards	Ongoing	NWS – Joe Sullivan EMA -Jim McKinney	BIA, NWS, ARC, Metro EMA, KWPC, Codes and Regulations		Normal Operating Budget, Grants
4.6	**Meteorologic**	**Expand Snow Routes Outreach** LOJIC maps showing snow routes (live routes) should be more accessible/better advertised e.g., radio and media links, Metro TV. 4 Outreach to public/ advertise, maybe use Mayor's Media office. 4 Show GPS, real-time Expand Operation Snow & Transportation planning 4 Staggered release plan to ease traffic before snow storms, esp. downtown	Ongoing	LOJIC - Curt Bynum, Metro Public Works - Phil Gardner	Metro EMA, KIPDA, LG&E, Metro EMS, Radio Media, Time Warner Cable, MSD, Metro Solid Waste, TARC, LMPD, Mayor's Office, NWS		Normal Operating Budget

Strategy Number	Hazard Type	Type of Activity or Project	Proposed Schedule	Lead Implementer & Contact Person	Other Proposed Partners	Benefit-Cost Prioritization	Funding/ Budget Considerations
5.1	Geologic	**Public Outreach Strategy To Specific Geologic Hazard Areas** 4 Develop standard outreach for areas at-risk according to risk assessment 4 Disseminate to targeted areas and to partner website, media, Metro Council districts …	Ongoing	Metro EMA - Jim McKinney, KGS - Drew Andrews	MetroCall - 311, Metro United Way - 211, Develop Louisville, Metro Public Works, MSD, LOJIC, Metro Council, Media outlets, LFPL		Normal Operating Budget, Grants, Metro Council discretionary funds
5.2	Geologic	**Develop an Earthquake Risk Assessment With Best Available Building Data** **Collect All Enhanced Building Data.** A major research project: 4 Year built, especially structures older than 1980 4 Type of foundation, building construction type, number of stories * tied to All Hazards public building inventory project.	Ongoing	LOJIC - Curt Bynum	Fire Departments, Codes and Regulations, Develop Louisville, LMPD, Metro Facilities, Metro Public Health, Local Hospitals, PVA, JCPS, UofL Department of Urban and Public Affairs		Resources needed Request from state or federal funding or grant
5.3	Geologic	**Earthquake Risk Assessment: Research the Existing Collected Data and Incorporate Inventory into LOJIC** PDS completed collecting public historical data. Next steps: 4. Historical Structures Survey. 5. Inventory of public buildings: review data for accuracy and completeness. 6. Incorporate data into LOJIC Metro Planning Design Services (PDS) and Property Valuation Administration (PVA) will work with LOJIC to coordinate the inventory.	Ongoing	LOJIC -Curt Bynum, Develop Louisville - Joe Haberman	PVA, Metro Public Works, Metro Facilities		Normal Operating Budget, Grants, Metro Council discretionary funds
5.4	Geologic	**Earthquake Mitigation: Target critical and Essential Public Buildings For Mitigation Or Retrofit*** 4 Develop a standard method for structural soundness and asset tie-downs (i.e. heavy bookcases, equipment). 4 Utilize proven success strategy and methods from JCPS 4 Will require evaluation of each public building **Dependent on completion of inventory and assessment. See All Hazards #1, 2, & 5.*	Dependent on completion of inventory and assessment	Metro Facilities - Mark Zoeller	Metro Public Health, Metro Public Works, LOJIC, JCPS, LFPL, Universities & Colleges, Daycare facilities		Grants

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5.5	**Geologic**	**Earthquake Education and Outreach to Schools** 4 Education in schools: K- 12 / colleges / universities 4 Emphasize take the information home 4 Use National Earth Science Education Standard for kindergarten - 12 http://www.uky.edu/KGS/education/edustand.htm 4 Utilize JCPS & KY EQ drill as standard.	Ongoing	JCPS - Dave Self	KGS, Universities & Colleges, Parochial /Private Schools, KyEM, Metro EMA		Normal Operating Budget
5.6	**Geologic**	**Earthquake Training & Outreach National Level Exercise 2011 May 16-20, 2011** Active participation in Madrid Fault training, May 2011, National Level Exercise 2011 (NLE-11). KyEM in planning phases for this exercise. Each EM Director will activate their EOC process, most likely during the first day of the event. There will be an opportunity for LEPC interaction. http://www.ready.gov/nle2011/index.html The purpose of NLE 2011 is to prepare and coordinate a multiple-jurisdictional integrated response to a national catastrophic event – specifically a major earthquake in the central United States region of the New Madrid Seismic Zone. NLE 2011 will involve thousands of government officials at the federal, state, local and tribal levels, members of the private sector, and the general public. Participants will conduct simultaneous, related exercise activities at command posts, emergency operation centers and other locations in the Washington D.C. area and the eight affected central U.S. states (Alabama, Arkansas, Illinois, Indiana, Kentucky, Mississippi, Missouri, and Tennessee). The functional exercise will offer agencies and jurisdictions a way to validate their plans and skills in a real-time, realistic environment and to gain the in-depth knowledge that only experience can provide.	Ongoing	KyEM - Mike Dossett	LEPC, Metro EMA, LWC, LG&E, USACE - Don Walker		Normal Operating Budget
5.7	**Geologic**	**Karst/Sinkhole Risk Assessment** **Data collection to inventory sinkholes** 4 Dye tracing by KDOW to detect sinkholes. Partner with KGS. 4 Will require coordination and meetings with KGS, KDOW, and MSD to determine next steps and to build a schedule	Ongoing	KDOW - Carey Johnson KGS – Drew Andrews	MSD PDS LOJIC		Normal Operating Budget, External funding for materials

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5.8	**Geologic**	**Karst/Sinkhole Risk Assessment** **Data collection to inventory sinkholes** Using high-resolution aerial imagery and geophysics to assess high-hazard areas for incipient cover collapse sinkholes 4 Develop strategy to phase project or as one larger project to accommodate funds and time. Could be a Phased 1 to 4 yr project. 4 LOJIC to be recipient of the resulting digital data, and a central repository for the report	Ongoing, used latest data in 2016 risk assessment	KGS – Jim Dinger	LOJIC		Normal Operating Budget, Part-time to 1.5 Full-time Employee
5.9	**Geologic**	**Karst/Sinkhole Risk Assessment** **Project to collect standardized info to protect existing, new and future buildings/infrastructure** 1. Need a central local agency or avenue to report and receive info for karst/sinkhole locations indicated on development plans per new karst regulations. 2. Need a central local agency or avenue to report and receive info for karst/sinkhole damages and events 3. Develop SOP or Policy Development 4. Store loss inventory, esp. for roads, buildings and utilities	2017, Ongoing	Develop Louisville - Joe Haberman	Metro Public Works, Metro Parks, LEPC, MSD, NRCS, KGS, LOJIC, Codes and Regulations, KYTC, Metro EMA		Normal Operating Budget, Grants, Metro Council discretionary funds
5.10	**Geologic**	**Karst/Sinkhole Public Outreach/Education/Warning** 4 Develop strategy for outreach/warning 4 Post warnings and barriers be posted around sinkholes on public lands 4 Develop Signage	Ongoing	Metro Parks - Jason Canuel	Metro EMA, Metro Public Works, Suburban cities, NRCS Future Fund 21st Century		Normal Operating Budget, Grants, Metro Council discretionary funds
5.11	**Geologic**	**Certification Process for Regulations in Development Code for Karst/Sinkhole** 4 Training Program, as needed	Ongoing, annual training	Develop Lousville - Joe Haberman	Planning Commission, Codes and Regulations, NRCS, KGS, LOJIC		Normal Operating Budget
5.12	**Geologic**	Karst/Sinkhole **Mitigation: Repairs to public lands and facilities** 4 Parks 4 Government owned	Ongoing	Metro Public Works - Jeff Brown, Metro Parks - Jason Canuel, Metro Facilities - Mark Zoeller	MSD KYDOW LOPC LOJIC Future Fund 21st Century Metro Parks		Normal Operating Budget, Grants, Metro Council discretionary funds

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5.13	**Geologic**	**Landslide Risk Assessment** **Project to Collect Info to Protect Existing, New And Future Buildings/Infrastructure from landslides** 4 KGS can be a central local agency or avenue to report and receive info for landslide, including damages and events. o Develop method to partner and receive info 4 Research what has been looked at in the past. LiDAR will assist with this element.	2017, Ongoing	KGS -Drew Andrews	Develop Louisville, Codes and Regulations, Metro Parks, LEPC, MSD, NRCS, KGS, LOJIC, Planning Commission, Metro Public Works		Normal Operating Budget
5.14	**Geologic**	**Update Risk Assessment Data collection for landslides** 1. Inventory septic tanks that can cause landslides o Metro Public Health currently has personnel working to geo-code the locations of septic systems o Estimates show over ½ of Anchorage have septic tanks 2. Collect data from other sources 3. Aggregate data	Ongoing	Metro Public Health - Steve Hosch and Matt Rhodes	PVA, LOJIC, Codes and Regulations, Develop Louisville, City of Anchorage, KGS, Metro Facilities, MSD		Normal Operating Budget, Grants, Metro Council discretionary funds
5.15	**Geologic**	**Landslide Mitigation: Project to Enforce Current Regulations And Protect Infrastructure** 4 Enforce Binding Elements 4 Limit clearing of vegetation on high-risk slopes 4 Ensure BMPs for drainage	Ongoing	Develop Louisville - Dave Marschal	PVA, LOJIC, MSD, Metro Codes and Regulations		Normal Operating Budget, Grants, Metro Council discretionary funds
5.16	**Geologic**	**Landslide Mitigation: Repairs and Reforestation To Public Lands and Facilities** **Reforestation** 4 10,000 tree initiative (see Flood # 21) **Repairs to** 4 Parks 4 Government owned	Ongoing	Metro Parks - Jason Canuel and Mesud Duyar	Metro Sustainability, MSD, KDOW, LEPC, LOJIC, 21st Century Parks		Normal Operating Budget, Grants

Strategy Number	Hazard Type	Type of Activity or Project	Proposed Schedule	Lead Implementer & Contact Person	Other Proposed Partners	Benefit-Cost Prioritization	Funding/ Budget Considerations
6.1	Other Hazards	**Promote Public Education for HazMat Activities and Sheltering in Place** 4 Promote sheltering-in-place 4 Promote education of hazmat activities 4 Utilize print, Metro-TV, and other media.	Ongoing	Metro EMA - Jim Bottom, LEPC	ARC, Metro TV, APCD, Media, JCPS, EMA, MSD, Metro Public Health		Normal Operating Budget, Grants
6.2	Other Hazards	**Develop HazMat Public Education/ Awareness/Training For Business Community** Encourage companies with chemicals to consider the effects of natural hazards on their stock of hazardous materials and negative impact on employees and/or public.	Ongoing	Metro EMA - Jim Bottom, LEPC	APCD, Metro Public Health, Metro EMA, MSD		Normal Operating Budget, Grants
6.3	Other Hazards	**HazMat Outreach to Individuals And Small Businesses Promote Spill Plans** to individuals and small businesses that have hazmat, but aren't required by law to have a spill plan. Outreach to: 4 Encourage storing materials in a safe manner above flood potential or anchoring tanks etc. 4 Make available "industry best practices" for handling haz-mat. 4 For small companies, KOSHAs education and training division could be a good resource.	2017, Ongoing	Metro EMA - Jim Bottom, LEPC	Metro Codes and Regulations, Small companies, KOSHA, Metro Public Health, APCD, MSD		Normal Operating Budget
6.4	Other Hazards	**HazMat Risk Assessment: Develop methodology and system for collecting and categorizing hazardous materials** by location, type, quantity, and potential consequences. Data to be managed by Metro EMA and continually updated for inclusion in hazard mitigation plan risk assessment and emergency planning.	2017, Ongoing	Metro EMA - Jim Bottom	MSD, Metro Fire, APCD, Metro Public Health, KOSHA, Suburban fire districts, Metro Codes and Regulations, Businesses, Louisville Forward		Grants, Normal Operating Budget
6.5	Other Hazards	**Develop Method for Collecting Drought Data** 4 Information on historic data 4 Estimates for losses 4 Dates of occurrences	Ongoing	NWS - Mike Callahan	KDOW, LWC, MSD, NRCS		Normal Operating Budget
6.6	Other Hazards	**Drought Mitigation: Drought Damage and Outreach/Education** WHEN Drought occurs, Outreach and education to keep the public informed should include 4 Foundation cracking outreach: Promote public awareness, soil shrinkage can lead to cracking in foundations – solutions are to water the lawn and the foundation 4 Drought leads to fire hazards, including wildfire	Ongoing	EMA -Jim McKinney	NRCS, MetroCall - 311, Metro United Way - 211, LWC, LEPC, Agricultural extension, Metro Public Health, Metro Fire, Suburban Fire districts, Media outlets		Normal Operating Budget

Strategy Number	Hazard Type	Type of Activity or Project	Proposed Schedule	Lead Implementer & Contact Person	Other Proposed Partners	Benefit-Cost Prioritization	Funding/ Budget Considerations
6.7	**Other Hazards**	**Extreme Heat Public Outreach & Education** 4 Coordinate with non-traditional agencies for community outreach	Ongoing	NWS – John Gordon	VOAD, Coalition of Homeless		Normal Operating Budget
6.8	**Other Hazards**	**Extreme Heat Public Outreach & Education Promote National NWS Campaign** 4 Propose Louisville be a test bed to promote child heat safety in vehicles. 4 Advisory Committee promote via partnerships,	Ongoing	NWS – John Gordon	Metro EMA, Metro EMS		Normal Operating Budget
6.9	**Other Hazards**	**Extreme Heat Public Outreach & Education** 4 Animals and sheltering during a disaster 4 Develop ideas for public service piece on MetroTV and other media outlets	Ongoing	Animal Control - Jessica Jo Montgomery	ARC, Salvation Army, VOAD, Media outlets, MetroTV		Normal Operating Budget
6.10	**Other Hazards**	**Extreme Heat Mitigation:** Louisville Metro region adopt policies incentivizing or requiring minimum albedo levels at the time of routine roof, street, and parking lot resurfacing and for all new development.		Metro Sustainability Office - Maria Koetter	Public Works, Develop Louisville		Normal Operating Budget
6.11	**Other Hazards**	**Extreme Heat Mitigation:** Louisville Metro region set tree planting and green roofing goals by district, enhance tree cover through a public tree planting program, and protect existing canopy through the adoption of a comprehensive tree protection ordinance.		Metro Sustainability Office - Maria Koetter	Public Works, Develop Louisville		Normal Operating Budget, Grants
6.12	**Other Hazards**	**Extreme Heat Mitigation:** Incentivize or require increased energy efficiency for both public and privately owned buildings.		Metro Sustainability Office - Maria Koetter	Develop Louisville, Codes & Regulations		Normal Operating Budget, Grants, Tax Incentives
6.13	**Other Hazards**	**Extreme Heat Mitigation:** Cool materials and greening strategies be implemented in concert at the neighborhood level, and that energy efficiency programs be continued and expanded for the Louisville Metro region as a whole.		Metro Sustainability Office - Maria Koetter	Public Works, Develop Louisville, Codes & Regulations		Normal Operating Budget, Grants
6.14	**Other Hazards**	**Wildfire Public Outreach & Education** 1. Increase public awareness during drought about wildfire potential 2. Wildfire early warning (Red Flag) education and outreach 3. Increase public awareness and enforcement of no burn regulations 4. Develop standardized reporting system	Ongoing	Metro Fire - **Doug Recktenwald**, APCD - DJ Fountain	Suburban fire districts, LMPD, Metro Codes and Regulations, Media outlets		Normal Operating Budget, Capital Budget
6.15	**Other Hazards**	**Wildfire Mitigation: Clean up of damaged trees** 4 Partner with Metro Parks and Public Works	Ongoing	Metro Parks - Jason Canuel and Mesud Duyar, Metro Public Works - Jeff Brown	21st Century Parks		Normal Operating Budget, Capital Budget

Strategy Number	Hazard Type	Type of Activity or Project	Proposed Schedule	Lead Implementer & Contact Person	Other Proposed Partners	Benefit-Cost Prioritization	Funding/ Budget Considerations
6.16	Other Hazards	**Wildfire Mitigation: Acquire and deed restrict forested land** E.g. Jefferson Memorial Forest, greenways, and parks	Ongoing	Metro Parks - Jason Canuel, Lisa Hite, Bennett Knox	MSD, Develop Louisville, 21st Century Parks, LOJIC, PVA		Normal Operating Budget, Capital Budget, Grants for acquisitions
6.17	Other Hazards	**Wildfire Mitigation: Develop strategy for fire suppression** 1. Target wildfire at-risk census blocks 2. Promote Best Management Practices (BMPs) 3. Delineation of non-wooded areas susceptible to wildfire	Ongoing	Metro Fire – **Doug Recktenwald**	Metro EMA, LOJIC, Metro Parks, Suburban Fire Districts, Develop Louisville		Normal Operating Budget
6.18	Other Hazards	**Wildfire Outreach Coordinated among Emergency Response Groups about Standard for Reporting Grass, Wild Fire, etc.…** 4 Action to involve coordinated outreach among Fire Dept's, MetroSafe, and any other emergency response group as needed to increase awareness of the event tracking/reporting tools/processes currently used.	Ongoing	Metro Fire – **Doug Recktenwald**	Metro EMA, MetroSafe, Fire Chiefs Assoc., Jefferson County Fire Trustees		Normal Operating Budget

6. Plan Maintenance

Plan Maintenance Procedures

Requirement §201.6(c)(4) requires a formal plan maintenance process to ensure that the Mitigation Plan remains an active and relevant document. The plan maintenance process must include a method and schedule for monitoring, evaluating, and updating the plan at least every five years.

This section must also include an explanation of how local governments intend to incorporate their mitigation strategies into any existing planning mechanisms they have, such as comprehensive or capital improvement plans, or zoning and building codes. Lastly, this section requires that there be continued public participation throughout the plan maintenance process.

Once a plan update is approved, Louisville Metro must maintain and amend the plan as needed. A routine method and schedule for maintaining the plan is necessary to ensure continued risk reduction and loss avoidance.

Completing the plan maintenance process will keep Louisville on track and serve as the basis for the 2021 plan update. The process of monitoring the plan will provide Louisville Metro the opportunity to document progress in achieving mitigation goals. The planning team agreed that it is imperative to have stakeholder involvement for maintaining the plan to ensure the mitigation strategy is incorporated into the City's planning efforts, programs, and policy.

6.1. Monitoring Evaluating, and Updates

During the March 7 Project Team meeting, the Team decided to renew regular meetings of the Hazard Mitigation Advisory Committee in order to facilitate and document progress. The Advisory Committee will meet twice per year. Meetings will be open to the public and stakeholders who participated in the 2016 planning process will be encouraged to continue their participation. Additionally, the Advisory Committee will coordinate with the Louisville Silver Jackets Chapter in plan implementation.

Louisville Metro will also utilize Kentucky's Community Hazard Assessment and Mitigation Planning System (CHAMPS) to track mitigation strategies and apply for HMGP funding.

As appropriate, the Plan will be evaluated after a disaster, or after unexpected changes in land use or demographics in or near hazard areas. The Advisory Committee also will be kept apprised of a change in federal regulations, programs and policies, such as a change in the allocation of HMGP or PDM grant dollars. These evaluations will be addressed in the annual Progress Report for the Plan and may affect the Action Plan.

Progress on the Mitigation Strategies will be evaluated annually by the Advisory Committee and a progress report will be posted on the Louisville Metro Emergency Services website. The progress report is required under the CRS program and will be submitted to FEMA Region IV, the Kentucky State Hazard Mitigation Officer, and Kentucky Division of Water.

Louisville Metro will be responsible for the next five-year update in 2021, as required by DMA 2000.

6.2. Incorporation into Existing Planning Mechanisms

Louisville Metro will begin the planning process for a new comprehensive plan soon after this planning process is complete. Coordination with Develop Louisville has been ongoing and the Hazard Mitigation Plan will be an important component of the new comprehensive plan.

Incorporate the HMP into Existing Planning

Requirement §201.6(c)(4)(ii): [The plan shall include a] process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms such as comprehensive or capital improvement plans, when appropriate.

6.3. Continued Public Involvement

The Project Team determined that Louisville Metro will continue public involvement using the same methods as the 2011 Plan. As public and private stakeholders, the Advisory Committee contributes to open public involvement and as such oversees the process and ensures actions are incorporated in their respective agencies/organizations for hazard mitigation. In addition, the public is invited to Advisory Committee meetings. To maintain continued public involvement, the Mitigation Plan as well as annual progress reports will be maintained on EMA's website and referenced on MSD's website and comments will be officially registered.

Continued Public Involvement

Requirement §201.6(c)(4)(iii): [The plan maintenance process shall include a] discussion on how the community will continue public participation in the plan maintenance process.